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U.S. DEPARTMENT OF COMMERCE
Patent and Trademark Office

TECHNOLOGY ASSESSMENT & FORECAST

TATE UNIV
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DOCUMENTS COLLECTION

COUNTDOWN-TO-DAWN

Technology is barely 4000 years old -- hardly a day in the history of mankind. If, indeed, we could compress these 4000 years and experience them in just 24 hours, we would, at the end of that period, find ourselves standing at the dawn of a new day -- contemplating what we just experienced and facing the future with new wonder.

We would remember that yesterday began quietly, its sunrise marked by the sundials of the ancients. It was not until noon, on our telescoped time line, that hours were measured by wheel-driven clocks and crude compasses were being developed which would begin to widen the horizons for everyone. Early in the afternoon, the Chinese produced explosive powder -- by dusk to become gunpowder for the cannon of Baghdad. As the daylight faded, Hero of Alexandria amazed us with his reaction turbine experiments, as did Archimedes with his teachings of hydrostatics.

Rome fell in the darkness of night and Innovation slept until awakened in the early morning hours by Gutenberg and Copernicus. Barely three hours ago, we were presented with both the microscope and the telescope to help us see deeply within and far beyond our world. Less than two hours ago, the spinning jenny revolutionized the textile industry and the science of aviation began as men took to the air in balloons.

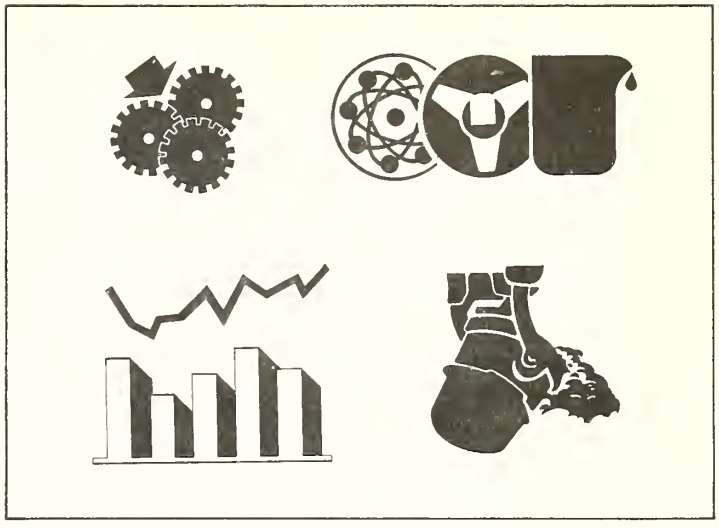
Only slightly more than an hour ago, this country and the U.S. Patent System were born. The pace of innovation became breathtaking. Whitney and Fulton stepped to the front -- followed by Morse, Bessemer, Edison and Bell. Within the past one-half hour we saw the discovery of radium, the invention of the electric light, assembly-line production of automobiles and the first powered airplane flight. Television and computers came on the scene only in the past quarter hour. Twelve minutes ago, the first atomic bomb blasted the world into a nuclear age. The space-race began seven minutes ago with the launching of Russia's Sputnik; three minutes ago, man viewed the Earth from the moon.

As the morning sky brightened, the closing moments before sunrise brought other miracles: micro-circuitry, computerized fuel injection; carbon fibers; imaginative applications for lasers; prostaglandins; wave guide transmission refinements; magnetic bubble domain memory systems; light emitting diodes; scores of technical improvements contrived at ever-quickening speed.

Now we scan the horizon in anticipation of what marvels this new day will bring--searching for a hint of the directions technological innovation might take.

NINTH REPORT • MARCH 1979

TECHNOLOGY ASSESSMENT & FORECAST



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INTRODUCTION*

Background

The Patent and Trademark Office has assembled one of the largest collections of technological literature in the world--the classified patent search file which contains twenty two million technological documents distributed among 100,000 subdivisions of technology.

Each year about 250,000 new U. S. patent documents are added to this file, along with 280,000 new foreign patents. A sizeable staff is engaged full time in reviewing this file and restructuring it to accommodate new technologies and changes in existing technologies.

In its own unique way, this file represents a national resource; and, the Patent and Trademark Office recognizes its heavy responsibilities not only to preserve, maintain, and improve the file, but, as well, to maximize its use for the greatest public benefit. It was as part of its effort to discharge this latter responsibility that the Patent and Trademark Office established, in 1971, its technology assessment and forecast program.

In its most general terms, the mission of the program is to stimulate and enhance the use and usability of the patent file, and to assemble, analyze and make available meaningful data about the file. In carrying out this mission, the Office of Technology Assessment and Forecast (OTAF), which administers the program, has assembled and built a master data base covering all U. S. patents. It periodically updates this base and strives continually to add new data items to it. Recent additions to the base are patent application date data, and relationships between the Patent Classification system and the Standard Industrial Classification (SIC) system. This latter addition permits, for the first time, broad scale use of patent data in economic studies.

OTAF uses the data base in two principal ways: First, it periodically issues general distribution publications. These publications have included reports on highly active technological areas; areas experiencing high levels of patenting by foreign residents; profiles of the patenting patterns of the residents of selected foreign countries and U. S. states; reviews of the patent activity of the most active patent assignees; and comparisons of patent activity with economic activity in selected Standard Industrial Classification categories. In addition, several of the publications have examined the patenting in high interest energy technologies.

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* The material on this and the following pages substantially duplicates that presented in previous publications. Those familiar with the Office of Technology Assessment and Forecast and the program it administers, may wish to begin reading on page 4.

A listing of previous OTAF publications and information as to how they may be obtained can be found in Appendix B.

The second principal use of the OTAF data base is made in the preparation of special reports, tailored to individual needs. These reports, which are provided on a cost reimbursable basis, have been utilized by other government agencies and a number of private sector organizations. More information concerning this special report service can be found in Appendix C.

Patents And Patent Activity

Over four million United States patents have issued since the first was granted on July 31, 1790. To facilitate the use of this large body of technology, these documents have been "classified" (categorized) into about 350 broad technological groupings (called Classes) and approximately 100,000 specific technological categories (called subclasses). Together, these Classes and subclasses form the structure of the classified patent file.

Copies of a patent are placed in more than one subclass of this file when the patent contains significant technology pertinent to more than one subclass. With such multiple placement or "cross-referencing" the patent file has grown to contain approximately 12,300,000 U.S. patent documents spanning the entire technological spectrum*.

Since a patent obtained in the United States conveys no protection outside this country, and vice versa, it is common in this age of the "international market place", for inventors to obtain patents in more than one country. As a result, significant foreign inventions are usually patented in the United States because it is such an important market. Thus, U.S. patent activity is representative not only of U.S. technological effort but, to a large extent, of foreign technological effort as well.

For example, the growth of foreign technological capabilities in the 1960's and 1970's has been mirrored by the growth, over the same period, of the share of U.S. patents granted to foreign resident inventors. In 1961, only about 17% of U.S. patents were issued to residents of foreign countries. However, by the end of 1977, the foreign share had increased to about 37%.

This apparent interrelationship between technological and patent activity gave rise to the basic premise of the technology assessment and forecast program - that patent activity is an indicator of technological activity, both domestic and foreign.

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* The file also contains 9.5 million patents of other nations and over 1 million pieces of non-patent literature.

Patent Data - Use, Meaning and Limitations

Patent data represent a comprehensive, in-depth technological activity information resource. The value of patent data is enhanced by the rarity of quantitative indicators which comprehend the entire technological spectrum and which are available in time series going back to the very beginnings of the United States. Patents, perhaps, are the only such indicator. Consequently, the potential uses of patent data are many and intriguing.

It has been only in recent years, however, that these data have begun to be considered for use to any significant extent. This is the case because patent data, on any but a gross or aggregate basis, have simply not been reasonably available to those who might like to use them.* With the advent of OTAF and its computerized data base, this inhibiting barrier to the use of patent statistics has, to a large extent, been eliminated and workers in many fields have been presented with a new tool.

As a new tool, the parameters of appropriate use for patent-data, its limitations and strong points, have not been well established and are themselves the subject of discussion and study. This is necessary and beneficial. It is one of OTAF's goals to advance and facilitate efforts to learn more about the legitimate implications that can be drawn from patent statistics. It is obvious that in the analysis of these statistics, many factors need to be considered. Among these are the variance between patents in importance and degree of invention. Also, the propensity to patent, as opposed to relying on patent alternatives (e.g., lead time in the market place and trade-secrets) may vary over time within an industry and between industries. These factors and others may well affect any use of, or conclusions drawn from, patent statistics. The more disaggregated the data, perhaps, the more important each of these factors become.

Yet, like the mountain, patent data are "there" and cannot (and we strongly believe, should not) be ignored. The data are becoming more available, more detailed, and more useable every year. In the final analysis, it cannot be denied that each patent represents, to some degree, a new piece of technology and, inferentially, some increment of technological activity. Together (in the hundreds, thousands and tens-of-thousands), patents reveal the "who, where and what" about substantial amounts of new technology and technological activity. It seems intuitively obvious then, that clear trends in patenting, especially within a given industry or technology, must be capable of telling us something.

It may be, as some allege, that patenting trends are more indicative of the health of the patent system than of the health of technology. Or it may be that the trends reveal more about the shifts in domestic technological

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* Jacob Schmookler, in his book Invention and Economic Growth (Harvard University Press, 1966) notes on page 21, that a year of effort was invested in the Public Search Room of the U.S. Patent Office collecting the data needed for his studies.

development than about the relative balance between domestic and foreign technology. On the other hand, perhaps they can indeed tell us much about where the U.S. stands overall or in any specific technology as compared to all other foreign countries or to any specific foreign country.

Most probably patent data tell us something about all these things, in some mixture yet to be determined. It will require investigation and study to establish to any widely accepted degree the true meanings of trends suggested by the patent data; but we are confident that the data's comprehenhensiveness and availability will stimulate this investigation and study.

In the interim, use of the data by OTAF and others for a wide variety of purposes will continue. For just as patents offer substantive technological information available nowhere else*, so do patent data offer a unique indicator of worldwide technological activity -- an indicator which, wisely used, may permit new insight into the complex interactions of technology and the economy.

About The Contents of This Publication

As with previous OTAF publications, this report illustrates the wide variety of uses to which patent information can be put. The four, widely divergent sections of the report examine patent activity from both a statistical and a substantive standpoint -- exploring patent activity as an indicator of technological activity and as a source of technological information pertinent to a given industry.

Section I inaugurates a new feature in OTAF publications -- one which is planned to be periodic. The OTAF report series has often focused on active technologies -- active in the sense of unusually high growth or foreign resident inventor activity. The technologies featured, however, have always been "selected", that is chosen on the basis, not only of their activity levels but also with attention to their potential reader interest. In addition, these technologies have usually represented homogeneous groupings of U.S Patent Classification system subclasses**, rather than single subclasses. Finally, a particular technology has seldom been reviewed more than once, even though its activity has remained high. This has been the case due to a desire to provide variety in the publications and to make them useful to as wide as possible an audience.

We have, however, received many suggestions and requests to provide a "top ten" kind of service which would provide, on a continuing basis, information on the areas of highest activity, without regard to previous coverage of an area. Consequently, in Section I, OTAF presents its "top fifty" -- the top fifty most active subclasses in each of three disciplines

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* See Section II "The Uniqueness of Patents as a Technological Resource", Eighth Report of the Office of Technology Assessment and Forecast (December 1977).

** The U.S. Patent Classification system is composed of about 350 major Classes which are further subdivided into about 100,000 subclasses.

(Chemical, Electrical and Mechanical) and in each of three categories (highest growth, highest growth rate and highest foreign resident inventor share). Although certain minimum criteria are set (for example, minimum threshold activity), no other selectivity is exercised. The top fifty in each discipline and category are listed on a strict ranking basis.

In Section II, OTAF continues its examination of patent trends - - dissecting recent domestic patent activity to shed light on the much discussed decline in domestic patenting. Also featured is a study of "unassigned patent" data. Traditionally, patents which, at time of issue, are unassigned (i.e., the inventor has not conveyed ownership of the patent to some organization, for example, a corporation or the government) have been thought to represent the inventive output of the independent inventor. However, some have called the reliability of these data into question, alleging that, because assignments prior to issue are printed on the face of the patent, many corporations routinely do not file assignments until after a patent issues in order to disguise the source of the invention.* If this were true, statistics as to patents unassigned at time of issue, widely used and cited as an indicator of independent inventor output, might be significantly in error. The study presented in Section II measures the extent to which patents, unassigned at time of issue, may be the result of organizationally supported technological activity, rather than the product of independent inventor activity.

In Section III, an in-depth review of patenting in ferrous metal technologies is presented. Similar to the treatment of computer memories in OTAF's Seventh Report**, and geophysical exploration for hydrocarbons in the Eighth Report**, the ferrous metal review is an extensive joint effort by several knowledgeable patent examiners. It is an attempt to demonstrate the wealth of information to be obtained from the patent file. The review is specifically aimed at creating an awareness of and stimulating an interest in the potential of patents as a source of technological information.

The final section of the report, Section IV, focuses on two experiments in the use of the patent file for the transfer of appropriate technology. The first experiment, being conducted jointly by OTAF and the University of Missouri-Rolla, is aimed at exploring the development of methodology by which the vast resource of technology contained in the patent file, much of

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* A patent is considered to be intellectual property which can be bought and sold. By law, transfers of patent ownership (assignments) must be recorded in the Patent and Trademark Office to protect the rights of the assignee. If an assignment is filed before a patent issues, that information is reflected upon the printed patent. If an assignment is filed after issue, no evidence of this appears on the printed patent. Patent and Trademark Office patent assignment files are open to the public but, at present, are not computerized and a manual search is required in order to determine current title to a patent.

** See Apendix B for specific citations and ordering information.

which is not published elsewhere*, can be usefully tapped by small business and industry. The second experiment, being conducted by the University of Denver Research Institute and the Pakistan Council for Scientific and Industrial Research, is aimed at determining the usefulness of patents, particularly older patents, to the needs of developing countries.

Though designed for very different uses and users, both experiments have much in common and both are concerned with the unique, essentially untapped potential of the patent file as a source of technology appropriate for many needs.

The Report concludes with four appendixes. Appendix A contains tables of corporate patenting data relied upon in Section II. Appendix B lists and briefly describes previous OTAF reports and explains how they may be obtained. Appendix C gives information about OTAF's special report services and includes excepts from samples of three "standard type" special reports. Appendix D names and acknowledges the assistance of the many Patent and Trademark Office personnel who have contributed to this publication.

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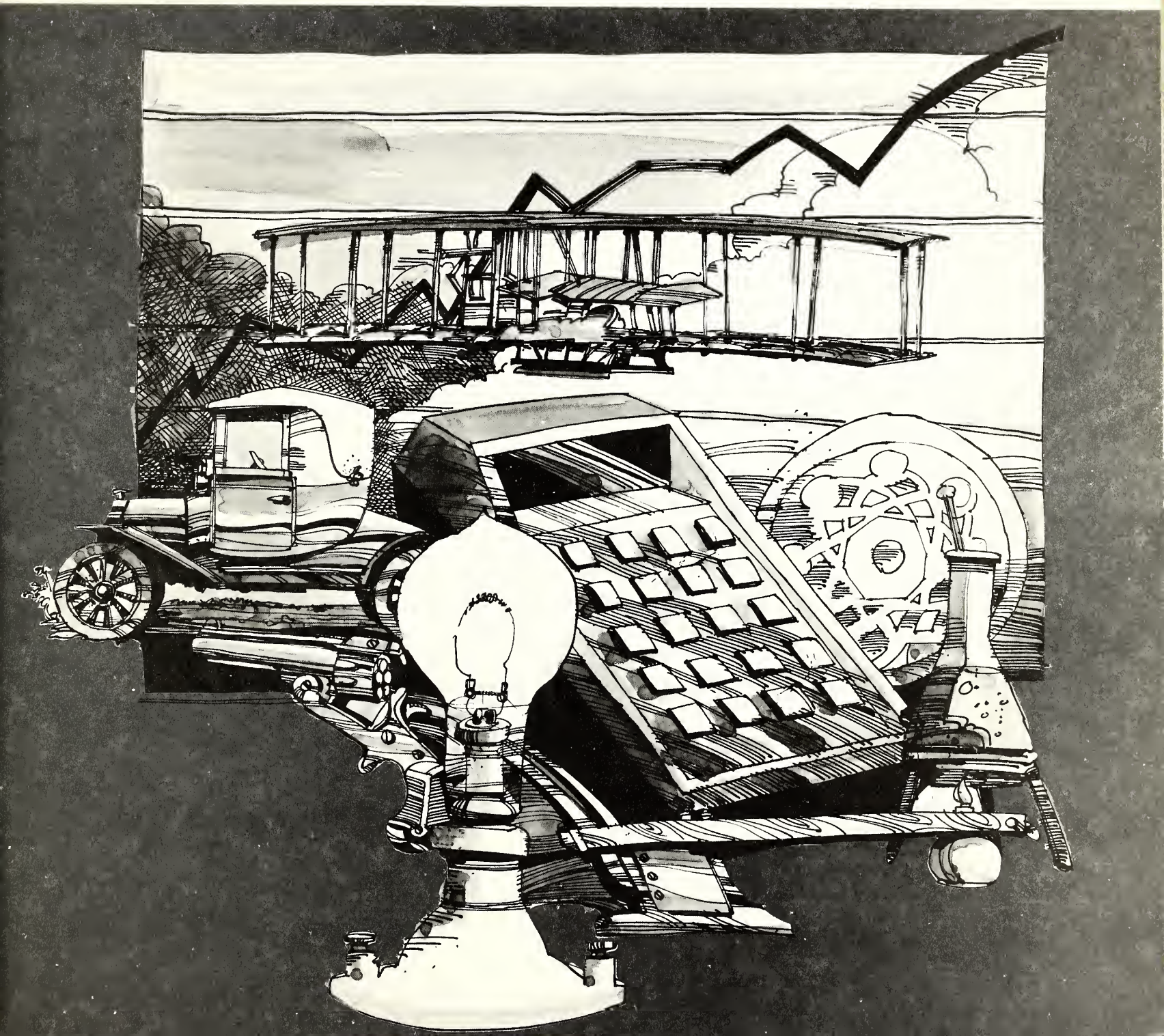
* See Section II, "The Uniqueness of Patents as a Technological Resource"; Eighth Report of OTAF, December 1977, which revealed that over 80% of the U.S. patents sampled contain technology not published elsewhere.

TECHNOLOGY ASSESSMENT & FORECAST

I

ACTIVE TECHNOLOGIES



SECTION I - ACTIVE TECHNOLOGIES

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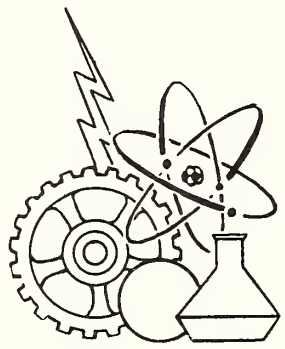

PREFACE

As implied in the "Countdown-to-Dawn" (back of front cover), the need for meaningful indicators of technological change has become increasingly apparent.

Assessing the technological activities of today may reveal trends which cast light on the paths man's innovative genius will follow in the future.

§ § §

Introduction

In this Section, OTAF takes a look at the recently active patent technologies* as determined from high-growth areas of the U.S. patent file. The hope is that such an analysis of development trends may prove to be a useful index in forecasting technology directions.

This Section begins with a brief tutorial outline of the U.S. patent file structure and a discussion of risks inherent in the use of patent data at the subclass level, the most elemental patent technology breakdown. Caveats in place and parameters explained, OTAF then performs a four-part patent activity analysis beginning with an examination of the actual file growth** of the top-ranked subclasses for each of the three major disciplines, Chemical, Electrical and Mechanical.

Following a detailed illustrative explanation of the difference between actual file growth** and percent (relative) growth**, is a review of the fastest growing patent subclasses.

Finally, noting in the foregoing analyses apparent discernable trends in foreign-orgin patenting, the technology areas experiencing the highest foreign activity are probed.

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*"Recently active patent technologies" are identified for the years 1975-1977 by ranking the top 50 patent subclasses by discipline (Chemical, Electrical and Mechanical) in each of three catagories:

MOST ACTIVE PATENT TECHNOLOGIES - - - - - - - - - TABLE SERIES A - - - - - - - - - Page 13

(ranked in terms of actual file growth**);

FASTEST GROWING PATENT TECHNOLOGIES - - - - TABLE SERIES B - - - - - - - - - Page 21

(ranked in terms of percent growth**);

MOST FOREIGN-ACTIVE TECHNOLOGIES - - - - - TABLE SERIES C - - - - - - - - - Page 28

(ranked in terms of percent foreign origin**).

**Terms defined -- page 11

Background

The U.S. Patent File Structure

As noted on page 1 of this report, the U.S. patent file grows each year by an average of 250,000 U.S. patent documents.* To facilitate an investigation or search of the scientific and technical information presented in these documents, now totalling more than 12.3 million U.S. patent copies, a systematic arrangement or subdivision of the subject matter was established.** This classification system has resulted in the creation of about 350 general categories or Classes distributed among the three major disciplines: Electrical, Chemical and Mechanical.

This classification system has been further refined to the extent that more than 100,000 subdivisions, called subclasses, are provided and maintained in a logical scheme or schedule within those Classes.

A Research Tool

It is important to reemphasize, here, that this file -- consisting of these 100,000 subclasses of technology ---is not fixed. It is dynamic, growing and everchanging to reflect the fast-changing state of technology.

It is the relative change in this file, measured over time, that OTAF has focused upon in an attempt to define the areas of most significant patenting activity, and thus, perhaps, the directions of technological growth.

Accepting the Risks

As with any analysis of this type, it is necessary that we take the risk of being misled by the statistics. It is well known among patent file experts that the subclasses were never "created equal" in terms of scope or content and, consequently, are often not directly comparable with each other in size and growth. In particular, some subclasses cover a wide range of subject matter within a generic title while others, parts of more highly defined schedules, are so exclusive in scope that their individual growth appears very small even though they may be components of a highly active, fast-growing technology. For example, a single subclass exhibiting a level of growth not particularly impressive by comparison with the av-

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* Each year roughly 70,000 new U.S. patents are added to the file along with duplicates for cross-reference purposes.

** Development and Use of Patent Classification Systems, U.S. Dept. of Commerce, January, 1966.

erage patent file growth, might thus be discounted at the outset. This same subclass, however, may be only one of a number of well classified, finely divided fractions of a definable whole, the overall (additive) growth of which might indeed be a significant, technology trend indicator.

Hence, caution must be exercised in drawing conclusions based upon the data presented. It is the purpose of this exercise to seek indications of trends rather than absolutes. For such purpose, the patent file offers unique capabilities.

Exercise Parameters

Aware of the shortcomings and pitfalls, OTAF determined to view the data in a number of different ways. Selected for comparison in each discipline -Chemical, Electrical and Mechanical- are the top 50 of the 100,000 subclasses ranked in each of three categories: (1) most active in terms of actual file growth*; (2) most active in terms of percent growth*; (3) most foreign-active in terms of percent foreign origin*. Subclasses were excluded from the percent growth and foreign origin ranking if they had less than thirty patent documents added during the three-year period examined (1975-1977). This minimum of thirty documents was set to avoid the misleadingly high percentages resultant in very small subclasses.

§ § §

Viewing the patent subclasses as specifically defined technologies, and keeping in mind the foregoing parameters, definitions and caveats, the stage is set for the first part of this analytical exercise.

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*Term definitions:

"Actual Growth" - Numeric increase resulting from additions of patent copies (including cross-reference copies)

"Percent Growth" - A measure of relative growth computed by dividing actual growth for 3-year period examined (1975-1977) by actual growth for 10 year period (1968-1977), and multiplying by 100.

"Percent Foreign Origin" - Foreign inventor share calculated by dividing total U.S. patents to foreign-resident inventors during 1975-1977, by actual growth for same period, and multiplying by 100.

Part I -- Most Active Patent Technologies

(Ranked by Actual Growth)

Extracting the Data

Scanning the approximately 100,000 subclasses to select those which experienced the greatest actual file growth in the three-year period, 1975-1977, resulted in the listings displayed in Table Series A which follows. Ranked by quantitative increase in patent documents (including cross-reference copies) are the top 50 for each discipline: -- Electrical, Chemical and Mechanical.

TABLE SERIES A

THE MOST ACTIVE PATENT TECHNOLOGIES

A-1 = ELECTRICAL
A-2 = CHEMICAL
A-3 = MECHANICAL

TABLE A–1. TOP 50 ELECTRICAL SUBCLASSES
(Ranked by Actual Growth)

Cl/Sub	Description	1975–77 Patents	% Growth	% Foreign Share	Total Patents
364/200	General purpose programmable digital computer systems	614	32.4	28.7	2392
350/160LC	Light control by liquid crystal lightwaves	484	66.4	48.3	729
364/900	Miscellaneous digital data processing systems	472	37.4	25.2	1867
357/23	Significant semiconductor potential barrier – insulated gate	311	31.3	37.0	1142
355/3R	Electric photography	294	36.7	35.7	968
357/30	Significant semiconductor potential barrier – light responsive (infrared to u. v.)	282	34.7	34.0	1175
357/24	Significant semiconductor potential barrier – insulated gate, charge transfer device	264	65.3	20.5	407
350/96WG	Optical waveguides for light transmitting fibers, rods or pipes	263	52.9	34.2	536
307/304	Special three or more electrode solid state field effect devices	246	31.5	34.1	900
350/96C	Connectors or couplers for light transmitting fibers, rods or pipes	235	83.9	36.2	280
350/35	Binocular-type compound lens systems	218	26.5	46.8	825
235/92R	Electrically operated registers	215	19.9	32.1	3140
58/5R	Calendar-type clock dials	211	56.1	47.9	635
307/238	Signal storage for nonlinear solid state devices	206	31.7	32.5	818
358/128	Television recording or reproducing discs	206	79.2	45.1	276
333/72	Piezoelectric transducer type wave filters for wave transmission coupling networks	193	40.1	40.9	647
307/221D	Analog shift register for nonlinear solid state counting devices	158	75.6	22.8	216
357/17	Significant semiconductor potential barrier – light emitting junction (infrared to u.v.)	156	34.4	51.3	517
250/227	Optical or pre-photocell system with light conducting rod	155	29.9	34.8	839
357/68	Ohmic contacts of particular geometry	152	24.0	40.8	1033
357/52	Significant semiconductor potential barrier – surface effects (passivation, guard rings)	149	24.8	45.6	1031
357/41	Significant semiconductor potential barrier – integrated chip, containing field-effect transistor	148	32.2	35.1	514
305/279	Field-effect transistor and/or integrated structure devices for signal shaping, converting or generating device	146	32.2	30.8	486
331/94.5G	Optical or quasi-optical oscillator with gas laser media	146	49.3	19.2	307
307/251	Three or more electrode solid state devices with field-effect transistor	145	24.8	32.4	674
357/15	Significant semiconductor potential barrier – metal semiconductor junction (e.g., Schottky barrier)	144	32.2	34.7	514
357/16	Significant semiconductor potential barrier – heterojunction	143	44.5	43.4	436
355/14	Automatic sequential copying and control for electric photography	142	42.9	35.9	420
219/216	Electrical heater for printing or reproduction device	141	42.7	35.3	398
357/59	Significant semiconductor potential barrier – polycrystaline	141	42.6	39.0	367
350/160R	Light control by altering optical medium, surface, or interface	193	21.9	31.1	1113
340/347AD	Code converters, encoders with nondiscrete input	190	25.6	37.4	1396
333/30R	Electromechanical transducer type delay networks for wave transmission	189	34.7	33.3	1051
58/23R	Electric clocks	186	45.4	61.8	629
330/4.3	Optical or quasi- optical laser-type amplifying device	186	80.2	19.9	297
340/324M	Matrix display systems	186	70.5	45.2	281
315/169TV	Plural diverse power supplies for television	181	41.0	34.8	653
357/91	Ion implant solid state devices	178	51.1	29.8	376
340/336	Monogram type advertising light display systems	164	47.7	54.9	471
346/75	Recorders with gas blast against receiver	163	54.0	38.7	380
357/55	Significant semiconductor potential barrier – discrete device with particular external geometry	163	28.8	40.5	1132
350/96R	Light transmitting fibers, rods, or pipes	162	27.4	40.7	1082
178/69.1	Telegraph synchronizer systems	161	39.3	36.0	644
310/313	Piezolectric surface acoustic wave devices	161	57.5	36.0	287
313/220	Electric lamp envelope with gas or vapor involving particular envelope structure	160	34.2	38.1	1114
307/205	Nonlinear solid-state devices with digital logic field-effect transistors	159	42.7	39.0	388
174/68.5	Preformed panel circuit conductor arrangements (e.g., printed circuits)	158	20.7	25.9	1349
250/338	Infrared responsive electric signalling device	138	41.3	17.4	540
331/94.5C	Resonator configuration for optical or quasi-optical oscillators (e.g., lasers)	138	25.9	15.9	582
328/167	Electron space discharge device system with filter for unwanted wave component	135	43.4	31.9	430

TABLE A–2. TOP 50 CHEMICAL SUBCLASSES
(Ranked by Actual Growth)

Cl/Sub	Description	1975–77 Patents	% Growth	% Foreign Share	Total Patents
424/267	Drugs and bioaffecting compositions wherein the active ingredient is piperidine or a derivative thereof	895	39.2	47.4	2906
424/250	Drugs and bioaffecting compositions wherein the active ingredient contains a three carbon-three nitrogen 6-membered ring	855	41.8	56.1	2544
424/246	Drugs and bioaffecting compositions wherein the active ingredient contains a 6-membered ring having at least 1 nitrogen and 1 sulfur atom	745	54.9	43.4	1589
424/274	Drugs and bioaffecting compositions wherein the active ingredient contains a 5-membered ring having 1 nitrogen atom	733	36.8	41.3	2704
424/263	Drugs and bioaffecting compositions wherein the active ingredient contains a pyridine bonded but not fused to another heterocyclic ring	692	43.6	50.9	2236
424/251	Drugs and bioaffecting compositions wherein the active ingredient contains a pyrimidine ring	551	44.9	45.2	1526
424/273R	Drugs and bioaffecting compositions containing diazole or a derivative thereof as the active agent	551	41.9	49.2	1799
23/2308	Analytical processes for use in biological systems involving combinations of tests or measurements with methods of regulating a reaction	444	49.2	19.8	1110
424/180	Drugs and bioaffecting compositions containing a carbohydrate as the active ingredient	406	52.3	48.5	1221
424/258	Drugs and bioaffecting compositions wherein the active ingredient contains a quinoline or isoquinoline ring	406	46.7	52.5	1231
424/317	Drugs and bioaffecting compositions containing a carboxylic acid or salt thereof as the active ingredient	385	46.5	40.5	1414
424/330	Drugs and bioaffecting compositions wherein the active ingredient is an aromatic amine (e.g., ephedrine or epenephrines)	384	44.0	45.6	1481
260/465D	Aromatic nitrile or isonitrile compounds substituted with acid, ester, acid halide, or acid amide groups	361	35.8	51.2	1533
148/1.5	Metal treatment process for producing barrier layer stock material	358	44.7	31.0	1250
148/187	Barrier layer stock material production process involving pretreatment of substrate before impurity infusion	356	37.2	34.3	1147
96/1.5R	Photographic developing processes using specific electrical conductive compositions	355	47.1	35.2	1058
424/270	Drug and bioaffecting composition wherein the active ingredient is thiazole or a derivative thereof	339	41.4	48.1	1084
424/244	Drug and bioaffecting composition wherein the active ingredient contains a heterocyclic group	337	33.2	39.5	1209
260/239.1	Penicillin compounds and derivatives thereof	330	50.9	59.1	1268
260/514D	Prostaglandin type carboxylic acids	328	76.5	22.9	429
195/103.5R	Methods for analysis or testing employing a fermentation step	322	45.0	29.5	1016
560/121	Carboxylic acid esters and processes for their preparation containing a cyclopentyl group in the acid moiety (e.g., prostaglandins)	319	65.1	21.9	503
260/40R	Synthetic resins containing a filler dye or pigment formed from the reaction of polycarboxylic acids with polyhydric alcohols	314	30.6	42.0	2007
252/522	Perfume compositions	312	50.2	52.2	917
424/177	Drugs and bioaffecting compositions containing a proteinaceous material as the active ingredient	309	55.1	42.4	1002
23/253R	Apparatus for determining qualitatively or quantitatively via a chemical reaction the presence of one or more chemical constituents of a material; or for measuring and controlling a reaction	302	27.6	29.8	1993
260/112.5R	Peptides of known chemical structure	290	46.6	45.2	942
424/275	Drugs and bioaffecting compositions wherein the active ingredient is a compound having a heterocyclic ring containing a sulfur atom	281	39.2	50.9	911
260/836	Mixed synthetic resins, graft copolymer or block copolymer, consisting of a polymerized polyoxirane component with a polymerized unsaturated compound	280	37.7	35.7	1031
260/268R	Piperazine and derivatives thereof	278	33.2	39.6	1486
428/425	Nonstructural laminate of urethane containing polyamidoester or polyisocyanate	276	37.3	37.3	920
148/175	Processes for growing contiguous layers of semiconductive material involving epitaxial depositing of semiconductor material and an impurity	270	34.1	37.0	963
252/408	Compositions for use in physical or chemical analysis, testing or indicating or as warning agents	267	37.3	29.2	1242
260/256.5R	Amino and sulfur substituted pyrimidines compounds	267	38.9	55.4	1162
424/271	Drugs and bioaffecting compositions containing a penicillin compound as the active ingredient	263	53.9	58.9	793
260/294.9	Compound containing a nitrile or isonitrile group	261	45.3	60.2	839
424/305	Drugs and bioaffecting compositions wherein the active ingredient is a carboxylic acid ester	261	62.1	42.1	472
260/340.9R	Organic compounds containing a 5-membered polyhetero ring and processes for preparing these compounds	259	36.8	41.3	1152
260/465E	Amino substituted aromatic nitrile or isonitrile compounds	257	34.3	52.5	1195
260/37N	Nitrogen containing synthetic resins to which a filler, dye or pigment has been added	256	27.3	45.3	1265
424/285	Drugs and bioaffecting compositions wherein the active ingredient is a compound having a 5-membered heterocyclic ring containing 1 oxygen atom	253	38.8	51.0	978
23/259	Laboratory devices that can be manipulated, useful for carrying out chemical reactions	252	37.7	31.0	1045
424/308	Drugs and bioaffecting compositions wherein the active ingredient is an aromatic carboxylic acid ester	252	43.5	44.8	827
424/316	Drugs and bioaffecting compositions wherein the active ingredient is an amine addition salt of an organic acid	250	61.3	51.6	608
96/35.1	Processes for producing designs which lie above or below a plane employing small light-sensitive molecules which react in the presence of light to form larger molecules	244	39.5	36.1	741
424/324	Drugs and bioaffecting compositions containing an amide of an aromatic acid or amine as the active ingredient	241	33.1	52.3	1115
426/656	Food products containing protein, amino acid, or yeast and their preparation	236	53.9	29.7	687
260/45.7P	Mixed synthetic resins, graft copolymers or copolymers containing a preservative consisting of a phosphorous compound	234	29.4	40.6	1234
260/501.1	Amine addition salts of acids	233	47.8	31.3	669
260/586R	Ketones – compounds containing the general formula RCOR wherein the R's may be same or different organic radicals	232	23.9	51.7	2214

TABLE A–3. TOP 50 MECHANICAL SUBCLASSES
(Ranked by Actual Growth)

Cl/Sub	Description	1975–77 Patents	% Growth	% Foreign Share	Total Patents
126/271	Solar water heaters	309	90.6	08.4	612
29/628	Electrical conductor or circuit manufacturing specifically including joining conductor to terminal or other conductor	224	31.5	23.7	982
197/1R	Typewriters – miscellaneous structure	206	55.4	36.9	783
123/148E	High tension electronic sparking devices for internal combustion engines	204	40.7	49.0	762
126/270	Solar powered stove or furnace	199	84.0	06.5	510
29/578	Semiconductor or barrier layer device manufacturing process involving surface masking	184	32.5	37.0	762
123/119A	Internal combustion engine charge forming devices using exhaust gas	184	53.0	58.2	676
128/287	Catamenial diaper and receptor	184	59.9	08.2	543
214/152	Processes for mechanically handling material or articles (e.g., power shovels)	181	34.5	27.1	1208
123/32EA	Electronically actuated forced fuel supplier for oil engines	175	40.8	76.0	494
29/580	Semiconductor manufacturing process involving shaping of semiconductor or foundation	174	43.8	31.0	568
128/284	Catamenial receptors or diaper	174	61.1	06.9	596
165/105	Condensing and evaporating systems for heat exchangers	168	33.5	32.7	805
128/260	Medicinal applicators or depositors	164	49.0	17.1	645
214/18B	Material or article handling, miscellaneous transfer devices	160	49.8	38.7	679
3/1	Miscellaneous artificial body members	147	42.7	27.9	458
350/150	Electro-optical polarization	146	23.8	50.7	826
131/17R	Tobacco product compositions	144	47.5	40.3	558
128/92C	Bandaging splints for bone fractures	142	62.0	46.5	243
60/641	Power plants utilizing natural heat	135	80.4	05.2	250
237/1A	Heating system with solar heat source	132	97.8	09.1	191
60/39.28R	Power plants with automatic fueling for regulating power output	131	32.6	33.6	1820
128/214R	Dosing devices for intravenous medicators	128	41.7	12.5	662
123/117R	Automatically controlled ignitor for internal combustion engine speed regulators	125	56.6	58.4	1318
128/2F	Diagnostic fluid collectors	117	42.2	20.5	325
128/276	Body discharge receptors with aspirators	114	43.3	12.3	486
123/32SP	Oil engine fuel injection system having spark spark plug in auxiliary chamber	109	80.7	78.9	225
29/625	Printed circuit making	108	20.9	29.6	1007
57/156	Processes for making spun, twisted, or twined yarns	105	32.6	81.0	621
57/34R	Textile spinning, twisting and twining apparatus combined with ancillary operations	103	34.8	85.4	440
29/577R	Process of making semiconductor electrical circuit assemblies	102	28.6	34.3	482
118/7	Coating apparatus including automatic control of coating material feed	102	34.3	29.4	510
100/53	Presses being interrelated or having safety controls	101	37.3	16.8	548
123/75B	Multiple intake for four-cycle internal combustion engines	101	72.7	74.3	426
123/119R	Charge-forming devices for internal combustion engines	101	18.1	68.3	1963
123/139AW	Internal combustion engine charge-forming devices including oil pump feed	101	39.3	80.2	531
303/20	Electrically controlled fluid pressure brakes	101	26.9	50.5	741
29/571	Process of making semiconductors for electric field-responsive device	100	34.1	36.0	361
29/589	Process of making semiconductors including securing to mounting or terminal	100	20.4	24.0	890
57/58.89	Free end yarn spinning device	100	45.0	91.0	262
123/32ST	Oil engine stratifed fuel injection system	100	70.9	71.0	200
128/1R	Miscellaneous surgical apparatus	99	28.6	14.1	562
308/72	Automatically adjustable bearings	99	42.3	33.3	1053
123/8.45	Single variable-volume-space rotary engines	98	48.0	33.7	390
29/526R	Assembling metal parts with fasteners	96	30.4	21.9	1360
220/9LG	Metal liquefied gas containers having spaced wall construction	96	48.7	54.2	347
29/626	Mounting electrical devices on printed circuits	95	18.5	23.2	938
128/272	Containers designed to hold solid, liquid or gaseous medicaments	94	43.1	16.0	721
166/274	Double fluid injection techniques for well processes	94	29.5	00.0	476
220/306	Metallic receptacle with detent retained closure	94	35.5	13.8	664

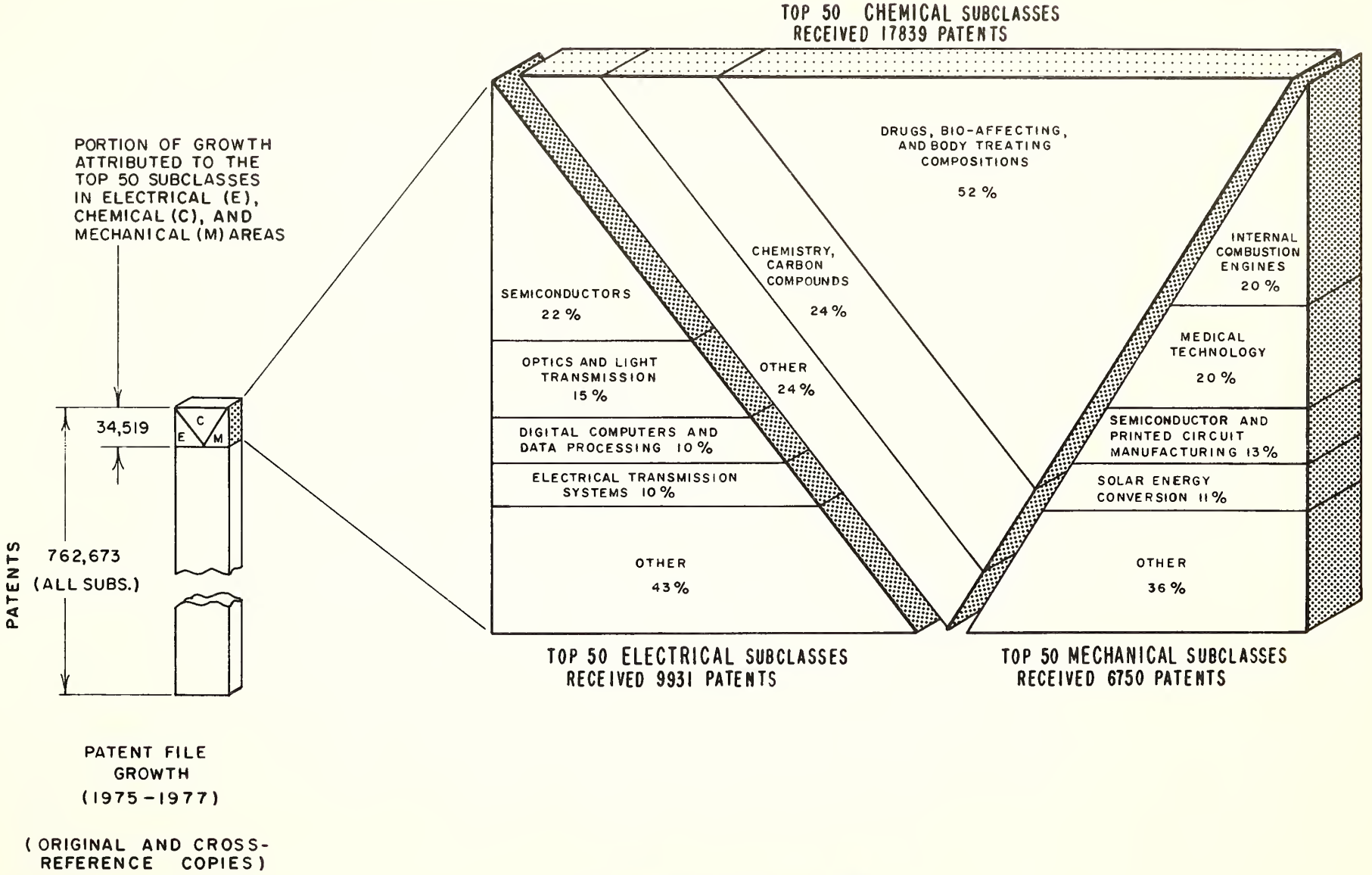
PORTION OF GROWTH ATTRIBUTED TO THE TOP 50 SUBCLASSES IN ELECTRICAL (E), CHEMICAL (C), AND MECHANICAL (M) AREAS
34,519
E
C
M
762,673
(ALL SUBS.)
PATENTS
PATENT FILE GROWTH (1975-1977)
(ORIGINAL AND CROSS-REFERENCE COPIES)
TOP 50 CHEMICAL SUBCLASSES RECEIVED 17839 PATENTS
DRUGS, BIO-AFFECTING, AND BODY TREATING COMPOSITIONS 52 %
CHEMISTRY, CARBON COMPOUNDS 24 %
OTHER 24 %
SEMICONDUCTORS 22 %
OPTICS AND LIGHT TRANSMISSION 15 %
DIGITAL COMPUTERS AND DATA PROCESSING 10 %
ELECTRICAL TRANSMISSION SYSTEMS 10 %
OTHER 43 %
INTERNAL COMBUSTION ENGINES 20 %
MEDICAL TECHNOLOGY 20 %
SEMICONDUCTOR AND PRINTED CIRCUIT MANUFACTURING 13 %
SOLAR ENERGY CONVERSION 11 %
OTHER 36 %
TOP 50 ELECTRICAL SUBCLASSES RECEIVED 9931 PATENTS
TOP 50 MECHANICAL SUBCLASSES RECEIVED 6750 PATENTS

FIG. 1-1 :

TECHNOLOGY DISTRIBUTION
OF
THE TOP 50 U.S. PATENT SUBCLASSES
IN EACH EXAMINING DISCIPLINE
RANKED BY ACTUAL FILE GROWTH

Fig. 1-1, on the previous page, is a graphical representation of information extracted from the three preceding tables. In each of the disciplines, Electrical, Chemical and Mechanical, the listed (most active) subclasses were, where possible, aggregated by general technology Of the total patent file growth attributed to all 50 listed subclasses in each discipline, that proportion for which a particular technology was responsible is shown in the exploded view. Note that in the three year period, all subclasses of the U.S. patent file grew by 762,673 U.S. patent documents (including cross-references). The 150 ranked subclasses (50 in each discipline), or only one tenth of one percent of all the patent file subclasses, accounted for 34,519 patent document additions, or 5% of the three-year growth.

Each of the groupings reveals a number of interesting patenting patterns.

Mechanical Subclasses

A total of 6,750 patent documents were added to the top 50 mechanical subclasses -- 37% of these were directed to energy-related technologies.

Topping the mechanical chart (Table A-3), with more than 300 added patent documents, is Class 126, subclass 271, to "Solar Water Heaters". This was once a nearly dead technology, now dramatically revived by increased innovation efforts driven by energy conservation and substitution needs. It is significant to note that other solar energy and natural heat conversion technologies appear in this listing: "Solar Powered Stove or Furnace," "Power Plants Utilizing Natural Heat," and "Heating System with Solar Heat Source." These are fast-growing technologies as indicated in the corresponding figures for Percent Growth (ranging from 80.4% to 97.8%, as compared to an all-technology average growth rate of 30.5%).* Interestingly, activity in these areas appears principally domestic in nature, since the figures for Percent Foreign Share are relatively low (5.2% to 9.1%, compared to an all-technology foreign share of 36.2% for the same period).

Internal combustion engine technology is a frequently occurring item in this listing of active subclasses. These subclasses, like the solar areas, exhibit high growth rates, but it is significant to note that the foreign share of engine innovations is unusually high.

Not to be overlooked is the significant number of subclasses in the Mechanical Table A-3 involving various forms of medical technology (ten of the 50 listed subclasses). Considered in conjunction with the high activity in drug areas as reflected in Fig. 1-1, the thrust of technology in medical directions is impressive. This may exemplify the relative importance placed upon patents by those in the medical field. However, a look at this from another viewpoint is provided on pages 25 and 26.

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* In subsequent parts of this Section, significance of these "Percent Growth" factors will be explored.

Electrical Subclasses

The Electrical Table A-1 ranks "General Purpose Programmable Digital Computer Systems" as most active of all electrical subclasses, receiving 614 additional patent documents during 1975-1977. "Miscellaneous Digital Data Processing Systems" turns up in third place with 472 additions. These two subclass areas were so active as to account for 10% of the total patent documents (9,931) added to all of the top 50 electrical categories. Such a high relative level of subclass activity obviously raises the question of subclass "scope" which was discussed on page 10 of this report.

A large number of subclasses (12 in all) are seen to involve various aspects of semiconductor technology and account for 22% of the total patent documents added to all top 50 electrical subclasses.

Electrical transmission systems are generally identified by six of the listed categories into which 10% of all documents added to the top 50 were filed. Optics and light transmission technology, including the fast-growing art of fiber optics, make up another significant portion of the active electrical subclasses (6 subclasses receiving 15% of all patents added to the top 50 categories).

Chemical Subclasses

The top 50 chemical subclasses, ranked by file growth (Table A-2), received a total of 17,839 additional patent documents during 1975-1977 (see Fig. 1-1). This list is dominated by two general categories. Twenty-one subclasses relating to the technological area involving Drugs, Bio-affecting and Body Treating Compositions, account for 52% of the added patent copies; 24%, by sixteen subclasses of Chemistry, Carbon Compounds (Organic Chemistry).

Illustrative of the high degree of activity in the chemical subclasses is the comparison between the Chemical, Electrical, and Mechanical Tables which reveals that the top listed chemical subclass (Drugs including piperidine as an active ingredient) grew by an amount nearly equivalent to the growth of the top electrical subclass and the top mechanical subclass combined. In fact, each of twenty-two highest listed chemical subclasses grew by an amount greater than that of the top-listed mechanical subclass. However, as explained in Part III (page 26) of this Section, inequities in classification refinement have resulted in a number of increasingly oversized subclasses, especially in the chemical areas.

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Included in the foregoing tables is an additional data element for each subclass-- the "percent growth" for that particular technological category. This information provides another perspective for analysis.

Part II -- Actual Growth vs. Percent Growth

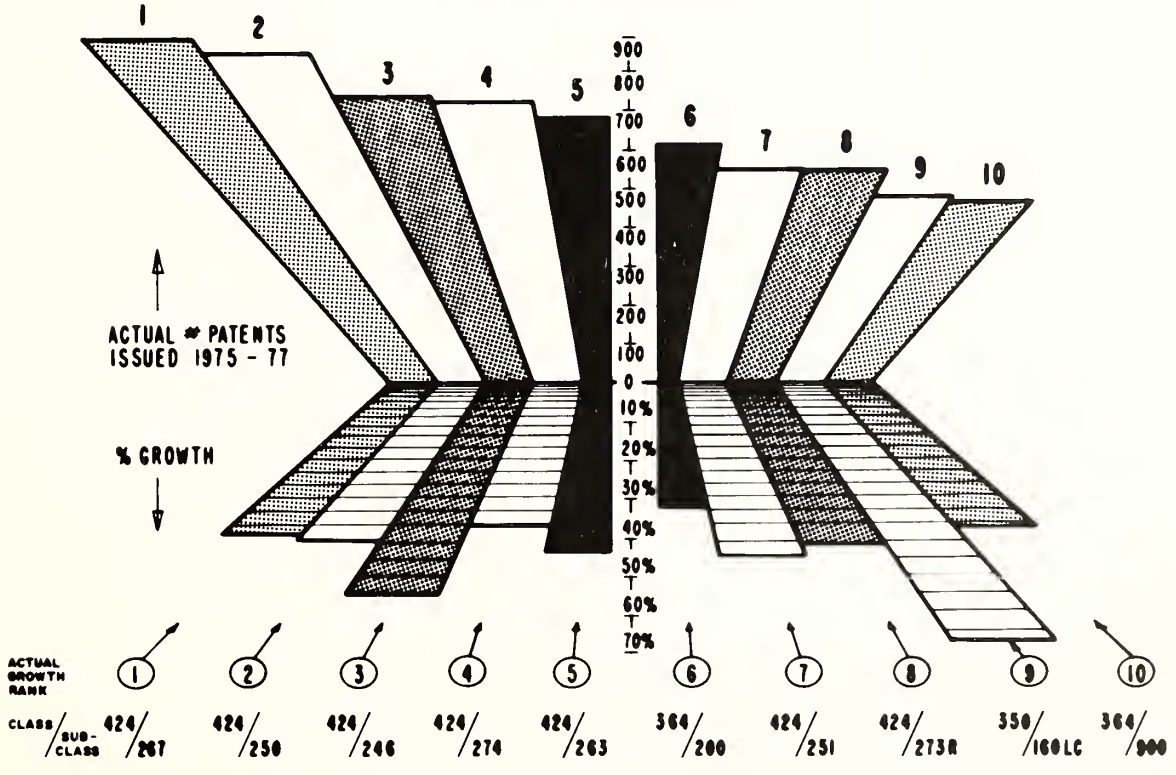
In the immediately preceding pages, an analysis was made of most active patent subclasses ranked in terms of actual file growth. Since each patent represents a direct result of activity in at least one technical field, much can be said for the value of raw numbers in technological measurement and comparision analyses. However, raw numbers do not tell the full story in the search for meaningful patterns and trends.

Another method of measuring file expansion is by percent growth over time. As noted before, OTAF computes this figure for a subclass by dividing the actual growth for the three-year period, 1975-1977, by the growth of that subclass over a ten-year period, 1968-1977, (multiplied by 100 to give a % rate). For example, a new subclass which experienced all of its growth during 1975-1977 would show a growth figure of 100%. Thus, a high value indicates recent activity.

The two methods of file expansion measurement -- raw growth and percent growth -- yield different results. For example, Fig. 1-2 shows the top ten subclasses ranked by actual growth (1975-1977) across all three disciplines. On the lower portion of this "shadowgram" the percent growth for each of the ranked subclasses is shadowed along a percentage scale. Since the average percent growth for all technologies for that time span

FIG. 1-2: ACTUAL GROWTH vs PERCENT GROWTH

TOP TEN U.S. PATENT SUBCLASSES
(RANKED BY ACTUAL GROWTH)



is around 30%, those of the top-ranked subclasses experiencing significantly more percent growth than average are more likely to be the "emerging technologies." A case in point is Class 350, subclass 160LC (Light Control by Liquid Crystal Light Waves), a technology known to be generating much recent industrial activity. Ranked as 9th on the "shadowgram," this technology displays a growth rate of 66.4% -- dramatic when compared to the 39.2% rate for the highest-ranked actual growth subclass (Drugs Including Piperidine).

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This gives rise to a second in-depth analysis of the most active U.S. Patent subclasses -- this time, ranked in terms of percent growth rather than actual growth.

Part III-- Fastest Growing Patent Technologies

Extracting the Data:

Assessing the U.S. patent file again for a ranking of the active subclasses, OTAF selected (from all 100,000) the top 50 in terms of percent growth, again for each of the three examining disciplines. The results are displayed in Table Series B.

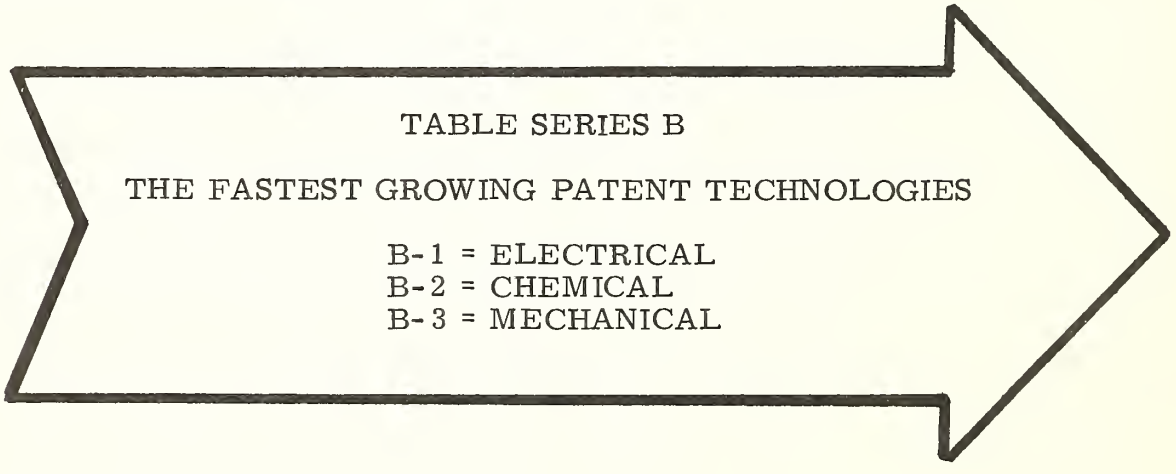

TABLE B–1. TOP 50 ELECTRICAL SUBCLASSES
(Ranked by Percent Growth)

Cl/Sub	Description	1975-77 Patents	% Growth	% Foreign Share	Total Patents
354/6A	Photoelectronic phototype composing	34	91.9	91.2	37
364/494	Generator control of electrical powered computers	37	90.2	08.1	47
365/183	Semiconductive systems with charge coupled insulated gate devices	52	85.2	07.7	63
219/10.55A	Pass-thru waveguides for electromagnetic wave irradiation	40	85.1	52.5	53
350/96C	Connectors or couplers for optical fibers, rods or pipes	235	83.9	36.2	280
364/712	Integrated circuits in electrical digital calculating computers	30	83.3	13.3	38
250/423P	Photoionization type ion generation	31	81.6	16.1	45
354/60L	Photoelectric light responsive device with lamp type electrical indicator	47	81.0	93.6	58
330/4.3	Optical or quasi-optical maser-type amplifying device	186	80.2	19.9	297
330/288	Semiconductive amplifying device including current mirror amplifier	47	79.7	08.5	59
358/128	Disc type television recording or reproducing equipment	206	79.2	45.1	279
364/400	Calculating computer and systems designed to solve problems other than mathematics	48	77.4	31.3	77
307/221D	Nonlinear solid state counting device with analog shift register	158	75.6	22.8	216
250/445T	Laminography	97	75.2	68.0	167
307/DIG4	Bootstrap capacitance in FET digital circuit	56	73.7	23.2	76
179/100.3Y	Spiral track photographic telegraphophone	126	72.8	65.9	221
307/DIG1	Electrical transmission interface circuits	75	72.1	26.7	105
364/431	Vehicle prime mover controlled by calculating computer	52	71.2	51.9	83
58/238A	Electric battery clocks	83	70.9	54.2	147
179/15AF	Multiplex telephony systems with pulse stuffing or deletion	31	70.5	51.6	46
340/324M	Communication systems with matrix display	186	70.5	45.2	281
365/43	Magnetic bubble chevron overlay	38	70.4	07.9	54
290/55	Wind-driven motors	36	67.9	16.7	199
179/100.1B	Telegraphophones: ferroelectric; electrostatic; pyrographic; resistance; etc.	31	67.4	09.7	100
290/53	Tide and wave motors	31	67.4	12.9	77
350/160LC	Light control by liquid crystal light wave device	484	66.4	48.3	729
357/50	Integrated semiconductor chip with combined P/N junction and dielectric isolation	96	66.2	36.5	148
360/99	Magnetic information storage flexible discs	60	65.9	18.3	106
307/DIG3	Electrical transmission system with sense-amplifier/comparator/latch	63	65.6	17.5	96
357/24	Semiconductor potential barrier insulated gate charge transfer device	264	65.3	20.5	407
364/426	Vehicle control and braking controlled by calculating computer system	32	65.3	46.9	59
315/411	Cathode ray tube circuits with power supply from deflectipn circuit source	42	64.6	52.4	88
219/10.55E	Electromagnetic wave irradiation cookware	38	64.4	23.7	85
307/DIG5	FET decoder circuits, digital responsive	56	64.4	21.4	87
340/15.5TS	Geophysical data telemetry communication systems	35	63.6	08.6	76
340/146.3SY	Stylus and writing instruments for character recognition communication systems	31	63.3	19.4	55
200/61.588	Seat belt electrical circuit making/breaking device	36	63.2	36.1	58
338/34	Resistance value responsive to gas, vapor or moisture collected or absorbed	39	62.9	46.2	114
360/113	Magnetoresistive or magnetostrictive recording head	32	62.7	34.4	74
58/4A	Electric calendar clocks	33	62.3	48.5	60
355/3DD	Dry developing electric photography	110	62.1	30.0	213
360/86	Disc record transport with head moving during transducing	45	61.6	28.9	136
179/1GQ	Binaural and stereophonic quadrasonic systems	97	61.0	59.8	161
354/23D	Digital photoelectric light responsive device	65	60.7	83.1	108
354/295	Camera operating attachments	34	60.7	44.1	133
307/10SB	Automobile seat and/or seat belt responsive electrical transmission systems	40	60.6	40.0	66
358/127	Television recording or reproducing device – non-disc type	81	60.4	48.1	179
340/15.5CP	Geophysical compositing communication system	32	60.4	09.4	87
358/148	Television synchronization device	38	60.3	60.5	179
340/52F	Electrical communication automatically responsive to vehicle conditions	50	60.2	52.0	111

TABLE B–2. TOP 50 CHEMICAL SUBCLASSES
(Ranked by Percent Growth)

Cl/Sub	Description	1975-77 Patents	% Growth	% Foreign Share	Total Patents
8/39C	Processes and composition for dyeing polyester fibers which employ nonvatted anthraquinone dyes	40	100.0	80.0	40
210/Dig.25	Processes and apparatus for mechanically removing oil from the surface of water	53	100.0	43.4	53
210/Dig.26	Processes and apparatus for physically removing oil from the surface of water	35	100.0	37.1	36
210/242S	Oil water skimmers	42	100.0	33.3	42
210/321A	Dialyzers	33	100.0	54.5	33
260/112.5LH	Luteinizing hormones of known chemical structure and methods of their preparation	39	100.0	17.9	39
260/289C	Compounds and their preparation containing a quinoline or isoquinoline nucleus, a polycyclic bridged or fused component, and an oxy or oxo group	38	100.0	52.6	38
260/307FA	Oxazolidine derivatives	40	100.0	40.0	41
260/520B	Arylalkanoic acid having an oxy group in the acid group side chain and their preparation	87	100.0	19.5	87
260/520C	Aryloxyalkanoic acids and their preparation	41	100.0	43.9	80
260/577	Secondary or tertiary aromatic amines having less than 12 nuclear carbon atoms	79	100.0	43.0	80
136/89PC	Photoelectric batteries having concentrators, orientators, reflectors or cooling devices	32	97.0	03.1	37
210/321B	Artificial kidney and lung devices	63	96.9	31.7	65
260/45.8NT	Synthetic resins containing a preservative a having 5 or 6 membered ring containing three nitrogen atoms	87	96.7	31.0	90
252/62.1L	Liquid developers for electrical and/or radiant energy images	53	96.4	56.6	55
252/62.1P	Powder developers for electrical and/or radiant energy images	84	94.4	28.6	94
427/385B	Processes for coating an article with a resin, rubber, or elastomer base coating involving further treatment of the coating after application	46	93.9	32.6	52
51/298A	Abrasive tool making process, materials and compositions which utilize a resin coated abrasive	30	93.8	30.0	32
260/287CF	Compounds and their preparation containing a quinoline or isoquinoline nucleus, three or more bridged or fused rings and an oxo group other than a keto or aldo group	44	93.6	61.4	55
260/288CE	Compounds and their preparation containing a quinoline or isoquinoline nucleus, an amino substituent and an extra cyclic hetero ring	53	93.0	66.0	60
23/288FC	Chemical apparatus for carrying out catalytic reactions which employ unitary catalysts	79	92.9	41.8	85
260/586G	Cyclic, nonaromatic ketones containing a bridged ring, spiro nucleus, and methods for their preparation	37	92.5	51.4	49
260/586P	Oxidation, oxidative dehydrogenation, dehydrogenation and hydrogenation processes for prepering cyclic nonaromatic ketones	92	92.0	56.6	113
260/59EP	Epoxy resin products prepered from phenol-formaldehyde condensation products	61	91.0	37.7	67
23/288FB	Chemicel apparatus for carrying out catalytic reactions which employ plural serially disposed catalytic stages	36	90.0	36.1	40
260/306.7C	Thiazolines or thiazolidines derivatives and their preparation containing an oxo group other than keto or aldo in the 4-position	71	89.9	56.3	79
210/516	Gravitational separators which are resilient end deformeble to permit insertion into the conteiner	39	88.8	00.0	63
260/288CF	Compounds and their preparation containing e quinoline nucleus, an amino substituent, end a fused ring on the quinoline ring	59	88.1	52.5	71
148/12F	Processes for heat treating and working low alloy ferrous metal	41	87.2	63.4	47
260/586F	Cyclic nonaromatic ketones containing a fused ring nucleus and methods for their preparation	53	86.9	60.4	72
544/21	Compounds and their preparation having a 6-membered hetero ring consisting of S, N, and C; cepham and cephem as two cyclos of a bicyclo ring system; and substituents in the 7, 7 positions	77	86.5	37.7	89
260/449R	Processes for hydrogenating carbon monoxide, and carbon dioxide products thereof	35	85.4	02.9	215
8/2.5A	Processes and compositions for dyeing textiles and fibers wherein the dye is transferred by sublimation to the surface to be colored	39	84.8	64.1	52
260/250BN	Compounds and their preparation having a pyrazine nucleus which contains nitrogen substituents	61	84.7	42.6	76
542/426	Heterocyclic organic compounds and their preparation containing an intercyclic olefinic chain, a noncarbon atom in the chain, and an alicyclic ring	98	84.5	44.9	118
260/586C	Condensation and cyclization processes for preparing cyclic, nonaromatic ketones	86	83.5	58.1	167
260/250B	Compounds and their preparation containing a pyrazine nucleus	43	82.7	34.9	56
427/151	Coating processes involving transfer or copy sheet making and which utilize reactive heterocyclic organic compound to produce or induce a color chenge	59	81.9	64.4	88
75/118R	Hydrometallurgical processes wherein the metal obtained consists mainly of gold and silver	62	81.6	45.2	79
536/10	Compounds and their preparation containing a kanamycin nucleus	31	81.6	58.1	49
252/173	Detergents for use on solid materials which contain a significant amount of water in the form of colloids and the like	53	81.5	26.4	158
260/346.75	Processes for preparing 5-membered polycarboxylic acid anhydrides involving a catalytic oxidation step	61	81.3	24.6	125
260/586E	Cyclic, nonaromatic ketones and their preparation containing a modified steroid nucleus	38	80.9	52.6	47
260/45.9NP	Synthetic resin compositions having a preservative compound containing nitrogen and phosphorous	40	80.0	17.5	53
260/558P	Carboxylic acid amides and their preparation wherein both the acyl and amine moieties contein an aromatic group	70	78.7	57.1	89
544/26	Compounds and their preparation having e 6-membered hetero ring consisting of S, N, and C; cephem and cephem as two cyclos of a bicyclo system; and a 3-position sulfur containing substituent	172	77.8	44.2	227
260/250P	Compounds and their preparation containing a phthelezine nucleus	35	77.8	71.4	53
260/287D	Isoguinoline derivetives end their preperetion substituted with a carboxylic containing group other then e keto or aldo group	35	77.8	62.9	65
544/27	Compounds end their preperetion having e 6-membered hetero ring consisting of S, N, and C; cepham or cephem as two cyclos of e bicyclo systerh; end a 7-position hetero-containing substituent	131	77.5	58.8	174
428/411	Lamineted stock meteriel consisting of plurel leyers of leminete cheracterized by the composition of the layers	150	77.3	36.7	241
260/306.7T	Thiazolines end thiazolidines compounds substituted in the 2-position with emino or imino groups end methods for their preperetion	51	77.3	58.8	66

TABLE B–3. TOP 50 MECHANICAL SUBCLASSES
(Ranked by Percent Growth)

Cl/Sub	Description	1975-77 Patents	% Growth	% Foreign Share	Total Patents
273/134AT	Board games controlled by chance (dice), with tracks having indicia	32	100.0	15.6	32
237/1A	Heating system with solar heat source	132	97.8	48.9	191
123/148CC	High tension electronic spark igniters with magneto capacitive discharge	30	96.8	53.3	31
241/DIG38	Solid waste disposal units	33	91.7	33.3	38
165/104S	Heat exchange apparatus with fluent material heat	31	91.2	22.6	37
53/305	Package-closing by hand operation – closure supply magazine	30	90.9	36.7	35
126/271	Solar water heaters	309	90.6	08.4	612
416/244A	Turbo impeller structure, housing and support	37	90.2	37.8	57
123/191SP	Internal combustion engine chamber with restrictive orifice	40	88.9	80.0	94
220/268	Nonremovable container closures (i.e., push-in pop tops for cans)	46	86.8	08.7	77
62/2	Refrigeration units using solar energy	30	85.7	13.3	170
214/DIG4	Material or article handling – roll handlers	45	84.9	11.1	152
126/270	Solar powered stoves and furnaces	199	84.0	06.5	510
123/32SP	Oil engine fuel injection system having spark plug in auxiliary chamber	109	80.7	78.9	225
60/641	Power plants utilizing natural heat	135	80.4	05.2	250
152/353R	External side walls of tires	31	79.5	51.6	45
280/605	Skis with pivotal brake members	31	79.5	93.5	73
123/191S	Auxiliary combustion chambers w/spark plug	54	79.4	74.1	141
172/59	Plural, driven earthworking tools – vertical axes	69	78.4	94.2	203
123/122AC	Engine charge forming devices wherein surrounding heating medium is provided with vaporization traps	40	76.9	45.0	142
123/3	Internal combustion engine w/means for generating and supplying fuel to engine	70	76.1	48.6	192
172/68	Earthworking device with rolling tool	31	75.6	90.3	250
165/18	Heat exchange device with automatic control of heat storage	30	75.0	30.0	117
123/122AB	Charge forming device wherein mixture to be heated adjoins heating medium	56	74.7	60.0	180
101/93.05	Wire type selective matrix character printer	44	74.6	36.4	106
126/121	Hot air fireplaces	54	74.0	07.4	359
128/2.05Z	Ultrasonic cardiac diagnostic devices	35	72.9	31.4	48
280/618	Ski with toe and heel fastener plate releasable from ski	67	72.8	76.1	112
123/75B	Multiple intake four cycle internal combustion engines	101	72.7	74.3	426
432/60	Material heating apparatus wherein a moving web, sheet or strand is flexed over a heated roll	85	72.0	28.2	146
432/106	Rotary drum furnaces with plural work chambers in series	60	71.4	85.0	250
123/32ST	Oil engine stratified air fuel injection system	100	70.9	71.0	200
152/330RF	Pneumatic tires with run-flat feature	46	69.7	65.2	90
209/74M	Assorting solids with automatic discharge memory	47	69.1	23.4	113
132/91	Thread holding toothpick	31	68.9	06.5	116
271/174	Sheet material delivering with transfer means between conveyor and receiver	39	68.4	53.8	76
308/DIG-1	Air bearings	39	68.4	38.5	244
3/1.91	Artificial bone joints	68	68.0	42.6	107
128/214D	Plastic disposable blood infusion bags	34	68.0	23.5	79
118/60	Drying by means of heated contact roll	65	67.7	12.3	271
73/114	Apparatus for measuring automobile miles per gallon	30	66.7	26.7	140
416/241A	Synthetic material impeller blades	32	66.7	21.9	58
60/682	Power plants with single state motive fluid energized by indirect heat transfer	35	66.0	31.4	139
273/134C	Chance controlled board games with cards	68	66.0	13.2	151
60/486	Power plants having plural energy input means, pumps or diverse pump outlets	92	65.7	30.4	263
246/34R	Railway signal systems with automatic, varying-current track circuit	38	65.5	10.5	630
60/276	Internal combustion engine having means to analyze the exhaust gas composition	66	65.3	83.3	125
60/282	Internal combustion engine having means producing chemical reaction of a component of the exhaust gas	72	64.9	86.1	120
280/11.37E	Attachments for skates, skis and ski poles	31	64.6	32.3	73
118/658	Xerographic equipment having stationary magnet with moving toner carrier	71	64.0	31.0	121

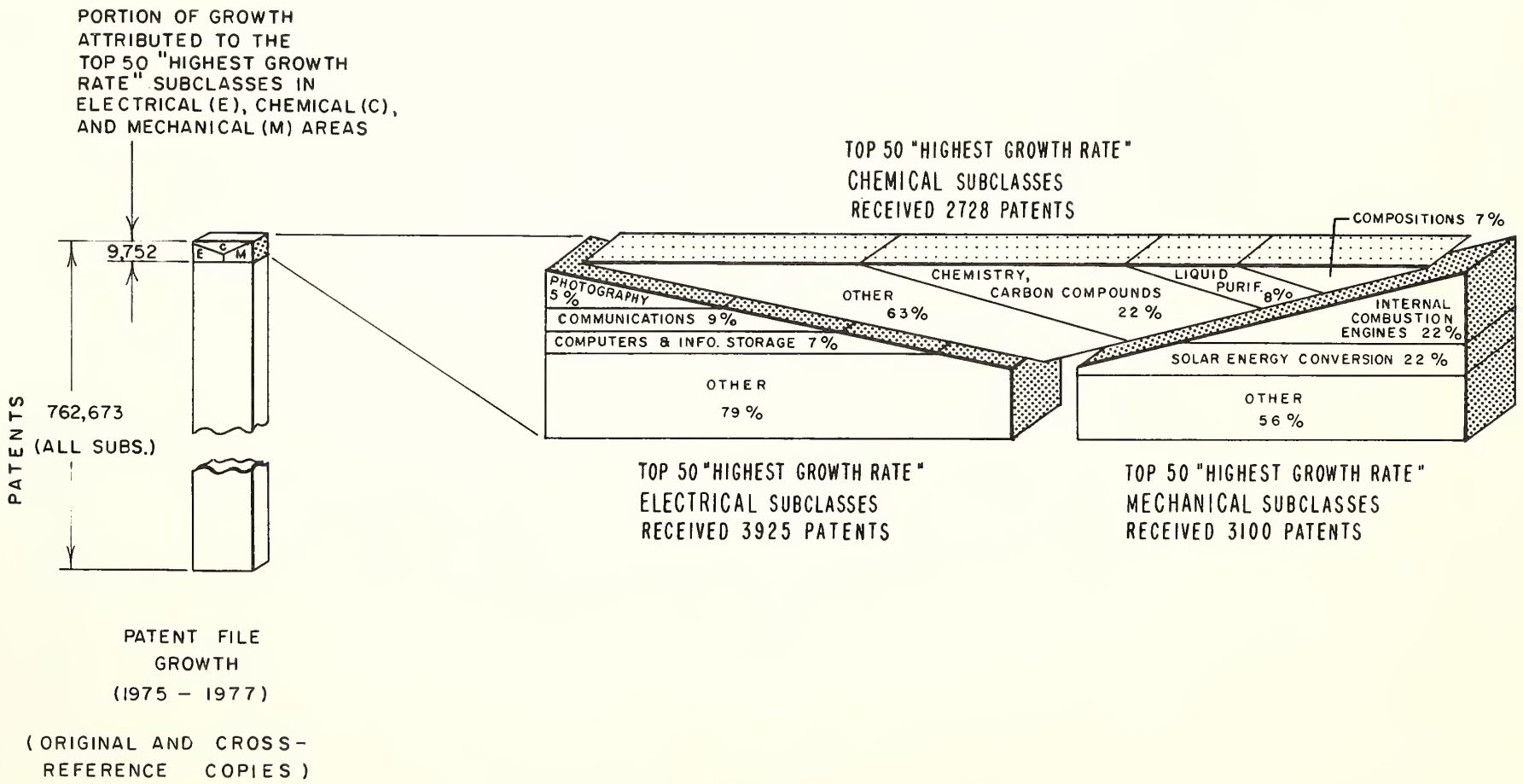
PORTION OF GROWTH ATTRIBUTED TO THE TOP 50 "HIGHEST GROWTH RATE" SUBCLASSES IN ELECTRICAL (E), CHEMICAL (C), AND MECHANICAL (M) AREAS
9,752
E
C
M
PATENTS
762,673
(ALL SUBS.)
PATENT FILE GROWTH (1975 – 1977)
(ORIGINAL AND CROSS-REFERENCE COPIES)
TOP 50 "HIGHEST GROWTH RATE" CHEMICAL SUBCLASSES RECEIVED 2728 PATENTS
COMPOSITIONS 7%
CHEMISTRY, CARBON COMPOUNDS 22%
LIQUID PURIF. 8%
PHOTOGRAPHY 5%
OTHER 63%
COMMUNICATIONS 9%
COMPUTERS & INFO. STORAGE 7%
OTHER 79%
INTERNAL COMBUSTION ENGINES 22%
SOLAR ENERGY CONVERSION 22%
OTHER 56%
TOP 50 "HIGHEST GROWTH RATE" ELECTRICAL SUBCLASSES RECEIVED 3925 PATENTS
TOP 50 "HIGHEST GROWTH RATE" MECHANICAL SUBCLASSES RECEIVED 3100 PATENTS

FIG. 1-3:

TECHNOLOGY DISTRIBUTION OF THE TOP 50 U.S. PATENT SUBCLASSES IN EACH EXAMINING DISCIPLINE RANKED BY PERCENT GROWTH

Fig. 1-3, on the opposite page, is constructed along the same lines as Fig. 1-1 on page 16. In this graph, as before, the subclasses listed in the foregoing tables were aggregated, to the greatest possible extent, into general technological categories. Note that, in this instance, the 150 ranked subclasses accounted for 9,752 of the total 762,673 patent documents added to the entire patent file during the period 1975-1977. Another point to note is that, even when several subclasses are grouped or aggregated into technological categories in formulation of the exploded segments of Fig. 1-3, such groupings account for only small percentages of the total patenting for each discipline segment. This indicates that the ranked subclasses cover a wide range of diversified technologies.

Looking at each discipline, there are at least a few readily discernable patterns or trends.

Mechanical Subclasses

Energy conservation and conversion technologies are again highly visible. Half of the listed subclasses in Table B-3 relate directly to energy technologies; ten percent involve solar energy and natural heat conversion techniques. It is particularly interesting in this context to note that the subclass for Solar Water Heaters, which was observed to lead the mechanical table for actual growth (see pages 15 and 17), ranks a high seventh place on this listing -- indicating a truly emerging technology notwithstanding its long existence.

Internal Combustion Engines subclasses appear frequently on this list as well as in the ranking for actual growth. Eleven of the 50 top-ranked subclasses are drawn to features in this category, with an unusually high foreign share ranging from 70 to 87%. Similarly, the specific pneumatic tire technology represented by two of the listed subclasses (from Class 152) appears heavily foreign-based.

Medical technology appears in this listing (in the form of ultrasonic cardiac diagnostic devices, artificial bone joints, and plastic disposable blood infusion bags), but not as frequently as in the previous set of tables based upon actual growth.

From the amusement class (Class 273), chance-controlled board games lead the mechanical listing -- all of that subclass growth occurred during 1975-1977.

Electrical Subclasses

While a large share of the high "actual" growth subclasses shown in Table A-1 were directed to semiconductor innovations (see pages 13 and 18), the percent growth of those particular categories was not sufficient to make this ranking list, except for one, subclass 24 of Class 357 (Semiconductor potential barrier--insulated gate charge transfer device).

Several categories of photography appear in this top 50 listing -- Photoelectronic phototype composing takes the lead with a 91.9% rate of growth -- all of these subclasses experiencing marked foreign activity.

Chemical Subclasses

Recalling the dominating presence of drug-related subclasses in the earlier listing by actual growth, discussed on page 18, the total absence of any of those technological categories in this percent growth ranking (Table B-2) is interesting and makes a significant point. It is apparent that while the drug subclasses are experiencing a great deal of activity, the recent file growth in those areas is not impressive, considering file size. As pointed out on page 10, meaningful conclusions based upon subclass comparisons are, in some instances, difficult to make because of differences in the refinement or breakdown level of classification. Chemical subclasses, as exemplified here, are sometimes too "broad" in scope and do not enjoy the level of subject-matter breakdown extant in other technological areas.

Recently developed technologies involving removal of oil from the surface of water ranked high on this table. Three separate subclasses directed to this category experienced all of their growth within the three-year span.

Carbon compound technology virtually dominates the percent growth listing. Almost half of the top 50 subclasses are directed to this technology. Referring to Fig. 1-3, it is seen that 22% of the patent documents added by the ranked chemical subclasses involved carbon compounds.

One of the leading chemical subclasses (experiencing 100% growth in 1975-1977) deals with chemical dyeing of polyester fibers -- Class 8, subclass 39C. It is significant to note that 80% of the 1975-1977 file growth in this subclass was the result of foreign-origin patenting.

§ § §

The noted high foreign activity displayed in the foregoing tables for many of the highly-active subclasses (ranked by both actual and percent growth) spurred OTAF to look at the data from yet another viewpoint. In which of the U.S. Patent subclasses have foreign resident inventors been most active?

Part IV -- Most Foreign-Active Patent Technologies*

Extracting the Data:

Next, OTAF selected those subclasses currently experiencing the highest percentage of foreign origin patenting. Again, the top 50 were ranked for each of the examining disciplines, Electrical, Chemical and Mechanical, for the three-year period 1975-1977. As a point of reference, it should be noted that the average foreign share for all U.S. patent technologies during that three-year period was 36.2%.

TABLE SERIES C

THE MOST FOREIGN-ACTIVE TECHNOLOGIES

C-1 = ELECTRICAL
C-2 = CHEMICAL
C-3 = MECHANICAL

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*In its Seventh Report and Eighth Report, OTAF presented an extensive, two-part analysis of international patenting patterns.

TABLE C–1. TOP 50 ELECTRICAL SUBCLASSES
(Ranked by Percent Foreign Share)

Cl/Sub	Description	1975–77 Patents	% Growth	% Foreign Share	Total Patents
354/24	Logarithmic photoelectric light responsive device	41	55.4	97.6	74
354/43	Light responsive device with diaphragm control by electric circuit means	38	30.2	97.4	180
354/204	Camera with interlocking film advance and shutter tension or setting	30	45.5	96.7	162
354/38	Light responsive device where light detector controls shutter or diaphragm	32	52.5	93.8	130
354/60L	Photoelectric light responsive device with lamp type electrical indicator	47	81.0	93.6	58
354/51	Light responsive shutter control including electric circuit with capacitor	117	41.8	92.3	298
354/60A	Oscillatory electric circuit means for light responsive device	34	91.9	91.2	37
354/60R	Light responsive device with electric circuit means	90	27.2	91.1	401
350/214	Multiple component lenses	69	31.1	89.9	326
354/234	Dynamoelectric actuated camera shutter	37	38.1	89.2	145
13/9R	Arc furnaces	33	14.3	87.9	772
356/226	Photoelectric photometer with plural detectors	41	28.7	87.8	255
354/50	Shutter control by light responsive electric circuit means	75	44.4	86.7	211
58/23D	Clocks with electric drives	37	43.0	86.5	118
310/268	Dynamoelectric generators w/disc type armatures	40	22.2	85.0	530
354/23D	Digital photoelectric light responsive device	65	60.7	83.1	108
354/152	Reflex camera with single objective	43	45.3	81.4	138
354/31	Plural light detector type light responsive device	41	36.0	80.5	142
354/44	Light responsive diaphragm control by electric motor	30	56.6	80.0	81
354/173	Electric film advance type motor film drive	50	51.0	80.0	153
350/187	Variable magnification lenses with adjusting mechanisms	39	31.7	79.5	269
350/215	Six component multiple lenses	34	27.2	79.4	234
350/176	Lenses having index of refraction greater than 1.8	43	31.9	79.1	185
250/202	Photocell controls optical system by following pattern	38	20.5	78.9	400
315/39.51	Distributed paratmeter resonator type magnetron	36	40.9	77.8	257
219/73	Nonatmospheric environment slag heating, e.g., submerged arc	44	29.7	77.3	303
310/12	Linear dynamoelectric generator	39	38.6	76.9	195
179/100.1TD	Three dimensional sound telegraphophones	38	48.1	76.3	211
318/138	Space-discharge-device commutated motor	90	22.3	75.6	647
350/255	Lens mounts with axial adjustment means	61	41.5	75.4	469
58/85.5	Watch setting means	108	52.4	74.1	361
318/254	Self-commutated impulse or reluctance motors	76	30.3	73.7	385
310/339	Voltage spark or current generators involving piezoelectric elements with mechanical energy coupling means	75	47.5	73.3	299
318/135	Linear movement motors	40	33.6	72.5	184
318/318	Automatic motor speed control device with electrical frequency detector of differences	31	37.8	71.0	176
358/44	Natural color television picture signal generator with single photosensitive device supplying more than one color signal	34	57.6	70.6	103
219/69C	Electric arc circuits for metal cutting of disintegrating	33	24.4	69.7	165
179/100.3G	Telegraphophones involving photographic light diffraction sound heads	32	46.4	68.8	124
250/445T	Laminography	97	75.2	68.0	167
250/311	Inspection of solids or liquids by electron microscope	54	30.9	66.7	321
310/49R	Step by step magnetic rotary motors	39	21.1	66.7	519
318/314	Automatic motor speed control device with electrical detector of phase differences	30	30.9	66.7	240
354/29	Light responsive shutter and diaphragm control with electric circuit means	44	55.0	65.9	85
179/100.3V	Spiral track type photographic telegraphophones	126	72.8	65.9	221
346/135	Record receivers and/or driving means with coated, laminated or impregnated bases	41	23.4	65.9	402
360/60	Dyamic magnetic information storage system with recording- or erasing-prevention feature	32	37.2	65.6	110
179/158T	Multiplex stereo system	78	47.6	65.4	419
250/360	Invisible radiant energy responsive signalling with relative movement means to inspect passive solid objects	49	39.5	65.3	169
354/33	Light responsive flash control circuits	34	32.4	64.7	110
350/184	Variable magnification lenses	48	28.2	64.6	321

TABLE C–2. TOP 50 CHEMICAL SUBCLASSES
(Ranked by Percent Foreign Share)

Cl/Sub	Description	1975-77 Patents	% Growth	% Foreign Share	Total Patents
96/56	Processes and compositions for obtaining colored images from exposed photographic film using a light sensitive silver compound, a dyestuff former, and a provision to prevent color fog or stain in the picture	33	39.3	97.0	177
96/124	Photographic compositions containing a light sensitive silver compound and two or more cyanine derivatives that act as sensitizers for the silver compound	33	37.5	93.9	119
8/1W	Dyeing processes or compositions containing one or more optical brighteners	47	52.8	91.5	192
548/310	Compounds, and their preparation having two 1, 3-diazole rings, each having divalent chalcogen or acyclic nitrogen double bonded directly at 2- and 4- positions	35	52.2	91.4	90
260/151	Azo compunds and their preparation containing a heavy metal or aluminum bonded to a phenylazonaphthyl group	34	34.7	91.2	449
96/111	Light sensitive, photographic compositions which contain an organic colloid and an agent which tans or hardens the colloid	44	27.0	90.9	330
252/301.22	Compositions containing an organic luminescent material which is a heterocyclic compound having an intercyclic acyclic methine linkage	32	37.2	90.6	138
96/56.5	Processes and compositions for obtaining colored images from exposed photographic film involving a light sensitive silver compound and a color former containing plural hetero nitrogen atoms	38	41.3	89.5	216
260/147	Azo compounds and their preparation containing a heavy metal or aluminum bonded to a pyrazol group	47	36.4	89.4	535
260/146D	Azo compounds and their preparation containing a heavy metal or aluminum bonded to a diazine	37	62.7	89.2	59
260/160	Azo compounds and their preparation containing a pyrazole group and two azo groups	31	39.7	87.1	314
8/54.2	Processes and compositions for dyeing cellulose fibers	70	25.1	85.7	852
260/146R	Azo compounds and their preparation containing a heavy metal or aluminum bonded to a heterocyclic group	61	27.2	85.2	1052
260/37NP	Synthetic resinous material containing an organic pigment which is suitable for melt spinning	33	27.0	84.8	123
260/196	Azo compounds and their preparation containing a naphthylazophenyl group	52	37.1	84.6	507
96/137	Light sensitive, photographic silver compositions containing a styryl sensitizer having three methine groups and a hetero ring fused or bridged to a carbocyclic ring	32	26.0	84.4	300
260/149	Azo compounds and their preparation containing a heavy metal or aluminum bonded to a monazo containing group	32	40.5	84.4	281
8/172R	Processes and compositions for dyeing artificial fibers involving treating the fiber, dye or dye bath with an organic nitrogen compound to enhance or complete the dyeing operation	42	24.4	83.3	442
8/177A8	Processes and compositions for dyeing polyacrylonitrile fibers which employ basic dyes	30	31.3	83.3	185
8/39R	Processes and compositions for dyeing textiles and fibers which employ nonvatted anthraquinone dyes	47	13.6	83.0	697
260/380	Compounds and their preparation containing an anthraquinonyl nucleus substituted with an amino and oxy group, the latter being bonded to a non-meso nuclear carbon atom	47	31.1	83.0	386
96/100R	Light sensitive, photographic silver compositions containing a developing ingredient and a dyestuff component to color the image	135	35.0	83.0	946
260/153	Azo compounds and their preparation that contain a triazine nucleus	58	30.7	82.8	457
260/378	Compounds and their preparation containing an anthraquinyl nucleus substituted with an amino group	46	36.8	82.6	347
260/163	Azo compounds and their preparation containing only 1 monocyclic azo component	62	32.1	82.3	661
8/177R	Processes and compositions for dyeing polyacrylonitrile fibers which use dyes or additives other than basic dyes or copper salt additives	33	17.8	81.8	572
260/239.3A	Processes for the preparation, recovery and purification of monocyclic lactams	44	29.1	81.8	329
8/10	Processes and compositions for dyeing skins, hair, furs, or feathers	71	41.5	81.7	302
260/155	Azo compounds and their preparation containing a quinoline nucleus	84	44.7	81.0	495
260/308A	Organic compound and their preparation containing a $\overline{N\text{-}N\text{-}N\text{-}C\text{-}C}$ nucleus	63	56.8	81.0	192
260/369	Compounds and their preparation containing an anthraquinoyl group	62	59.0	80.6	289
8/39C	Processes and compositions for dyeing polyester fibers which employ nonvatted anthraquinone dyes	40	100.0	80.0	40
195/47	Processes for preparing carboxylic acids or salts thereof involving fermentation of carbohydrates by living bacteria	40	35.7	80.0	269
260/158	Azo compounds and their preparation containing a thiazole nucleus	103	33.0	79.6	676
260/208	Processes for treating azo compounds, e.g., to convert them into compounds of different character or to purify them	44	55.0	79.5	371
260/157	Azo compounds and their preparation containing an azole group	83	39.5	79.5	501
195/28N	Fermentation processes wherein the starting material or fermentand is a nucleotide	39	25.3	79.5	241
195/29	Fermentation processes wherein the fermentands are proteins or amines	115	40.5	79.1	573
260/295.58	Pyridine derivatives and their preparation containing two fused rings and an oxo group (other than as found in ketone and aldehydes) in the β position	86	47.5	79.1	240
536/7	Compounds and their preparation containing a carbohydrate nucleus substituted with a cyclopentanohydrophenanthrene ring system and a five-membered hetero ring having at least oxygen as the ring hetero atom	33	45.2	78.8	147
424/182	Bioaffecting or body treating compositions wherein the active ingredient is a carbohydrate compound containing a cyclopentanophenanthrene moiety	47	43.9	78.7	146
260/154	Azo compounds and their preparation containing a diazine nucleus	103	41.9	78.6	510
8/41R	Dyeing processes and compositions employing azo dyes	60	14.5	78.3	1063
8/418	Processes and compositions for dyeing polyamide fibers which employ azo dyes	64	32.8	78.1	245
260/156	Azo compounds and their preparation containing a pyridine group	145	53.3	77.2	455
8/26	Processes and compositions for dyeing textile material which involve the use of several dyes, one of which is an azo dye, applied simultaneously or sequentially	39	35.8	76.9	218
260/117	Proteineous compounds which are gelatin, glue, or their reaction products (e.g., peptide material)	39	23.8	76.9	468
8/62	Processes and compositions for textile printing wherein the dye is applied to localized areas of the textile by impression or through openings of a stencil	43	33.6	76.7	458
425/373	Apparatus for shaping plastic articles or earthenware which includes a press couple defined by a roll coacting with an endless band	30	41.7	76.7	247
260/162	Azo compounds and their preparation that contain a pyrazole nucleus and 1 azo group	59	35.8	76.3	456

TABLE C–3. TOP 50 MECHANICAL SUBCLASSES
(Ranked by Percent Foreign Share)

Cl/Sub	Description	1975-77 Patents	% Growth	% Foreign Share	Total Patents
139/436	Textile weaving with stationary weft supply supply and progressive shredding	38	48.1	100.0	113
172/59	Plural, driven earthworking tools – vertical axes	69	78.4	94.2	203
280/745	Vehicle passive restraint safety belt systems	47	45.2	93.6	110
280/605	Skis with pivotal mounted brake member	31	79.5	93.5	73
57/58.95	Free end yarn spinning device combined with mechanical feeding means	74	40.9	91.9	212
57/58.89	Free end yarn spinning devices	100	45.0	91.0	262
60/285	Engine fuel, air or ignition controlled by exhaust gas reactor condition	52	55.9	90.4	108
60/277	Internal combustion engine exhaust treatment means having malfunction signal	31	55.4	90.3	93
172/68	Earth working device with rolling tool	31	75.6	90.3	250
61/45D	Mobile props for tunnel lining	80	36.5	90.0	322
303/119	Valve structure responsive to Solenoid operated cutoff and release valve	35	35.4	88.6	107
303/22R	Load control fluid-pressure brakes	61	34.7	88.5	448
101/12	Embossing Matrix material	34	63.0	88.2	134
66/50R	Special stitch, independent needle, circle knitting machine	59	39.9	88.1	334
60/282	Internal combustion engine having means producing chemical reaction of a component of the exhaust gas	72	64.9	86.1	120
66/154A	Electric or hydraulic pattern means for knitting machines	35	45.5	85.7	116
57/34R	Yarn manufacturing apparatus combined with ancillary operations	103	34.8	85.4	440
164/252	Metal founding involving application of electrical energy to work with an arc electrode	40	33.6	85.0	206
432/106	Rotary Drum furnaces with plural work chambers in series	60	71.4	85.0	250
57/56	Yarn spinning machines with clearing means	32	36.0	84.4	214
188/73.5	Retainer for wheel brake element preventing vibration of element	37	39.8	83.8	108
60/276	Internal combustion engine having means to analyze exhaust gas composition	66	65.3	83.3	125
57/106	Yarn twisting devices with yarn guiding or guarding means	35	25.7	82.9	363
74/866	Interrelated motor and transmission control via accelerator actuated electric signals	40	29.4	82.5	180
57/77.4	Friction type false twisting devices for yarn-making	49	43.0	81.6	197
60/323	Exhaust manifold having inlets from plural cylinders	38	46.9	81.6	173
432/14	Material heating operation including passing gas into or through particulate work	48	56.5	81.3	213
123/139E	Internal combustion engine charge-forming devices with electric oil feeding pumps	58	35.6	81.0	213
57/156	General processes for spinning, twisting and twining yarn	105	32.6	81.0	621
91/434	Expansible chamber motor with pressure responsive manual valve controlling inlet and outlet	31	45.6	80.6	314
188/181C	Comparative vehicle speed regulators	31	27.2	80.6	141
57/34HS	Heat setting of twisted yarns	61	26.9	80.3	385
123/139AW	Oil feeding pumps with non-electric supply to inlet	101	39.3	80.2	531
61/42	Earth control tunnels	30	39.5	80.0	254
123/191SP	Internal combustion engine chamber with with restrictive orifice	40	88.9	80.0	94
74/869	Accelerator controlled, hydraulically coordinated plural shift valves for interrelated motor and transmission	34	27.2	79.4	187
303/115	Fluid pressure brake with speed responsive actuating signal and pressure modulator	48	27.4	79.2	188
123/32SP	Oil engine fuel injections system having spark plug in auxiliary chamber	109	80.7	78.9	225
123/119D	Internal combustion engine charge forming devices with auxiliary air system	51	52.0	78.4	212
242/18DD	Drum driven bobbin and cop winding devices	51	49.5	78.4	233
192/98	Shipper saddle clutch operators	32	56.1	78.1	214
61/85	Earth tunnel shields	40	40.4	77.5	208
64/21	Uniform angular velocity flexible shaft couplings	43	31.6	76.7	466
242/47.12	Unidirectional cord winding device with lateral traversing means	30	42.9	76.7	123
24/205.16C	Multiple, integrally connected fasteners, including wire-mounting means	42	44.7	76.2	147
280/618	Ski with toe and heel fastener plate releasable from ski	67	72.8	76.1	112
123/32EA	Electronically actuated forced fuel supplier for oil engines	175	40.8	76.0	494
164/437	Continuous or semi-continuous casting of metal with means to dispense or distribute charge	33	35.1	75.8	133
104/148MS	Railway car propulsion systems with electric magnetic suspensions	49	50.0	75.5	107
53/167	Package-making device with various combined operations	36	35.0	75.0	297

As shown in Table Series C, the top 50 Electrical subclasses in this category ranged in foreign share from 64.6% to 97.6%; Chemical, 76.3% to 97%; Mechanical, 75.0% to 100%.

Aggregating the subclasses generally by technology within each of the noted disciplines provides the input for the graphical presentation shown in Fig. 1-4. Displayed as a segmented "Foreign Pipeline" cross-section is a technology breakdown of the top 50 foreign-active subclasses.

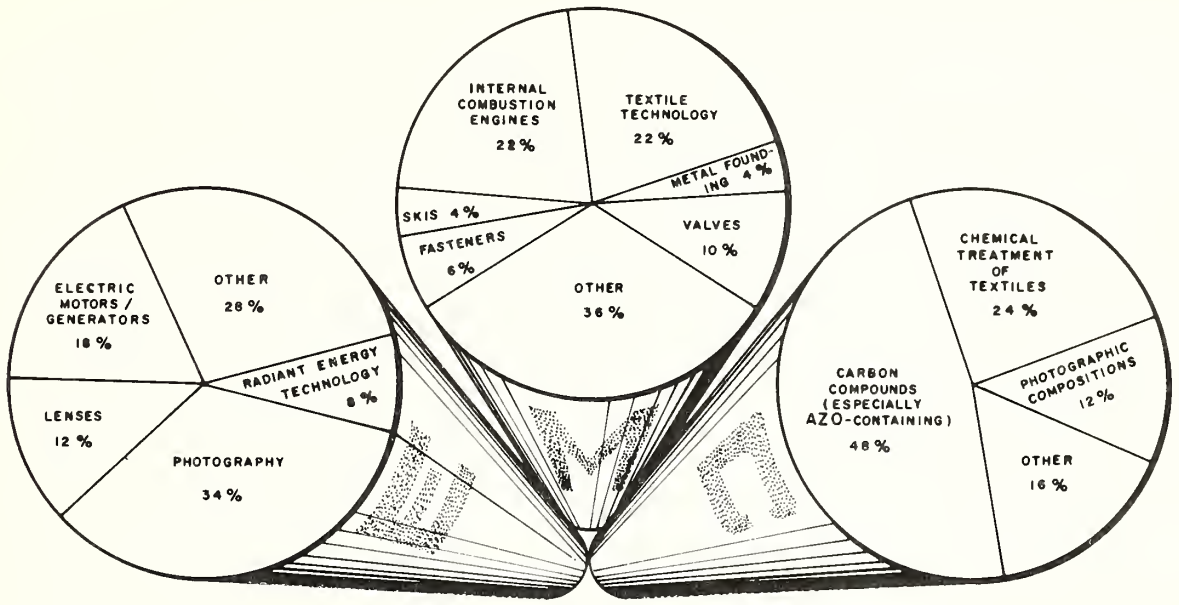

FIG. 1-4: THE FOREIGN PIPELINE
TECHNOLOGY DISTRIBUTION
WITHIN
TOP 50 SUBCLASSES
RANKED BY PERCENT FOREIGN SHARE
ELECTRICAL, MECHANICAL, CHEMICAL

It is no surprise that the photographic arts take a large share in both the electrical* and chemical areas. Foreign resident inventors have long held a technical lead in this area. The same may be said, of course, for "skis" in the mechanical area. Generally speaking, the fact that nearly one-half of the top ranked chemical subclasses in this category are directed to "Carbon Compounds, Especially Azo-containing" is, also, not surprising. These azo compounds are mostly chemical dyes - an area in which certain foreign countries have long been active.

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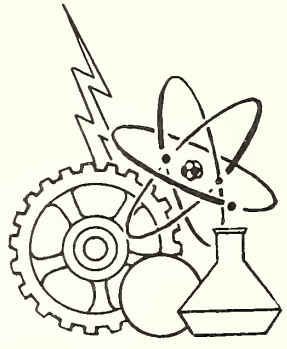
* Note: Photography, including cameras, lenses, etc., is classified in the Electrical discipline -- except for the purely chemical processes and products.

Obviously troubling indicators for certain struggling U.S. industries impacted by foreign trade flows, are the relatively high percentages of the most active foreign subclasses directed to "textile technology" (both mechanical treatment and chemical processes), "fasteners" of various types, and metal founding technology. (See Section III of this Report for an in-depth study of Ferrous Metal Technology.)



FUTURE REPORTS

Within a few months, OTAF's data file will again be updated. It will be interesting to see which patent class subdivisions will move to the top to the "most-active" lists. Which subclasses will have grown the most, and at the fastest rate? What will be the areas of greatest foreign-resident inventor activity?

In subsequent reports, OTAF plans to include, on a periodic basis, a section intended to provide a current examination of patent file growth. Hopefully, continuing and progressively refined analyses of this type will provide a useful insight into patterns of technological change.

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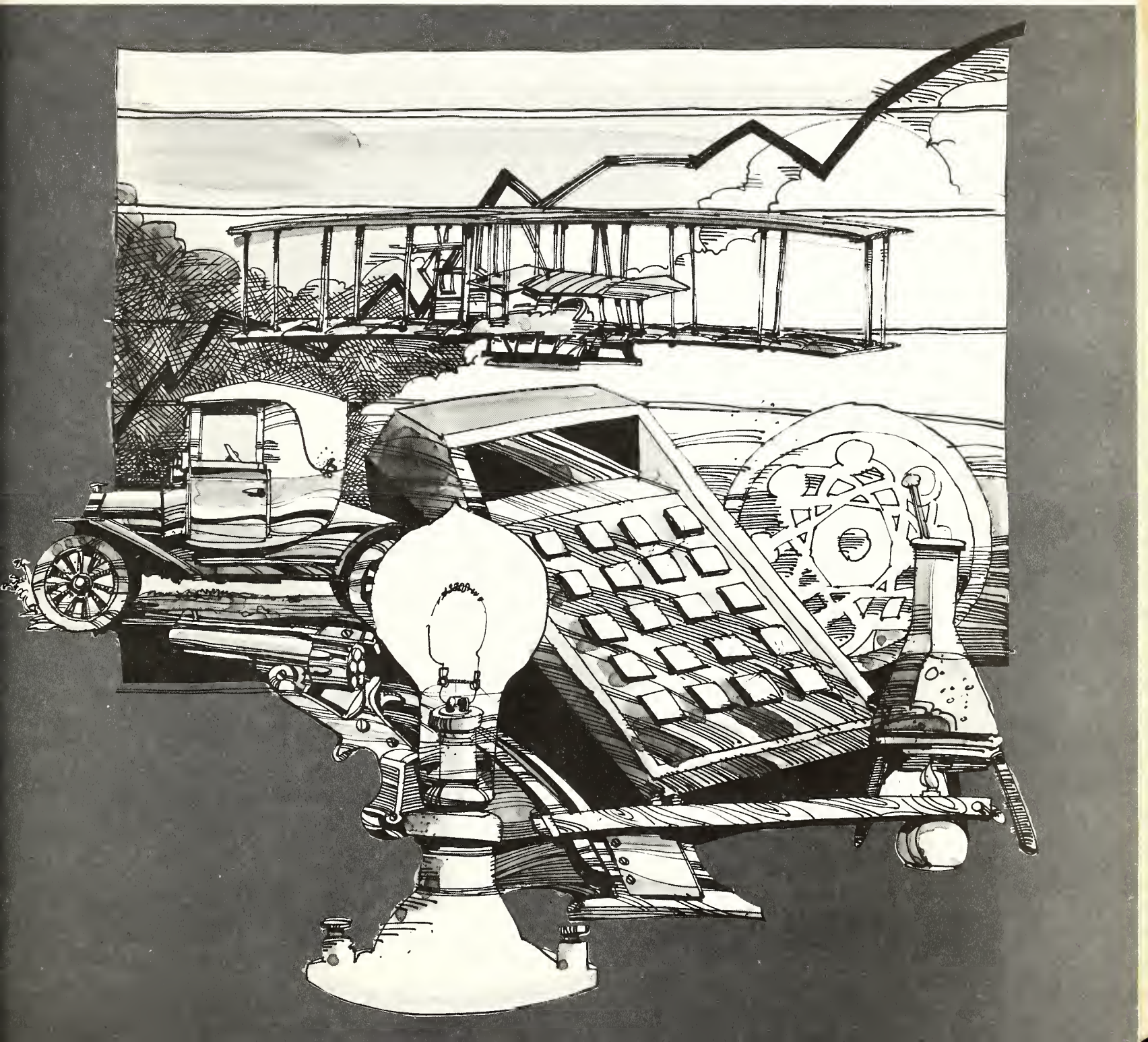
TECHNOLOGY ASSESSMENT & FORECAST

II

PATENT TRENDS



SECTION II - PATENT TRENDS

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Independent Inventor Trends 44

INTRODUCTION

In this section OTAF examines two aspects of patent data that are of interest to users of patent information - recent trends in domestic patenting* and the meaning of "unassigned patents" **.

Each of the previous eight OTAF reports has presented information on recent patenting trends. Two such trends, the increasing share of U.S. patents granted to foreign resident inventors and the leveling off of overall patent activity, are phenomena familiar to readers of these reports. These phenomena have been variously linked to increasing foreign competition in high technology markets***, to the demise of U.S. inventiveness****, as well as to a decline in the use of the patent system*****. Today, substantial disagreement exists among users of these data as to their meaning.

Statistics as to patents unassigned at time of issue have long been used as a measure of the inventive activity of independent inventors. Unasaigned patents stand as perhaps the only such indicator available across the entire spectrum of technology. However, because patents may be assigned after issue, some patents now construed as "unassigned" or inventor owned may really be corporate originated and owned. Hence, unqualified use of "unassigned patent" figures may overestimate independent inventor activity.

What follows are two brief studies dealing with these aspects of patent information. They are intended to shed some light on the meaning of patent activity data and hence contribute to an understanding of their use. Also, they are intended to serve as a demonstration of the utility of the OTAF data base which, hopefully, will act as a stimulus to the work of others interested in the field.

Domestic Patenting Trends

Recently, domestic patent activity trends have been used to indicate either a decline in American innovation or a decline in the use of the patent system by various segments of the economy. Significant to either viewpoint, and the focus of this study, are the following questions:

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* Domestic patents are defined an those having been granted to U.S. resident inventors.

** Refers to patents where the legal title is held by the inventor. Because a patent is intellectual property which may be bought and sold, legal title may be transferred to an organization or another individual, i.e., the patent may be "assigned".

*** Dennis Schieffel and Carol Kitti, Research Policy, Vol. 7, issue 4, p 324, (1978)

**** Wall Street Jounal (October 18, 1977)

***** Deborah Shapley, Science, Vol. 202, p 848-849 (1978)

- Are the allegations of a decline in domestic patenting accurate and, if so, can the decline be explained largely as an effect of the patent activity of any one segment of the patenting population?

- Have the ownership patterns, (e.g., corporate, government, individual) of U.S. origin patents changed in recent years?

Data Source - OTAF Data Base:

The OTAF data base contains data elements* that can be utilized in studies which address such questions. Also, because these data elements can be messaged and manipulated in any number of ways, the data base is a significant research tool to elucidate the role of patents in the innovative process and the national economy.

The data base covers patents granted from 1836 to 1977. Included is information, for patents granted beginning in 1963, on assignments**, i.e., whether the patent was assigned at time of issue to a U.S. or foreign government, corporation, or was unassigned. For patents granted beginning in 1969, the data base also records the specific assignee at time of issue, and the application date of the patent. *** Thus, when studying patent data organized by assignment, it is possible to analyze either the patents granted in a given year, or the patent applications filed in a given year which eventually resulted in patents (hereafter referred to as patented applications).

The availability of patented application data represents a significant step forward in OTAF's work on making patent data available for study. Patenting data distributed by application date are of significant value, for the date an application is filed is a more accurate reflection of when the technology was developed. Additionally, fluctuation in data based on application date is much more likely to reflect changes in technological activity, since such fluctuation would, for the most part, be immune from, rather than the result of, changes in Patent and Trademark Office (PTO) application processing.

Distributing 1967-1977 patents on an application date basis provides essentially complete data on those applications, which ultimately became patents, filed each year from 1965 through 1975. This is the case because there is a delay between the filing of a patent application and its subsequent issuance as a patent. The length of this delay (i.e., the "pendency" of an

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* A description of this data base is given in Appendix C.
** Assignment of a patent is the transfer of legal title, originally vested in the inventor, to a firm, the government, or another individual, etc.
***Application date data are available beginning with patents granted in 1967.

application) is determined by many factors, including Patent and Trademark Office workload (which varies between technologies), budget and manpower levels, patent printing schedules, etc.

In 1967, when maintenance of application date data in machine readable form began (and thus became subsequently available for inclusion in the OTAF database), the average patent pendency was substantially in excess of two years. Consequently, patent applications filed in 1965 and 1966 were not issuing as patents until 1967 or later.

By December of 1977, as a result of an ambitious and successful Patent and Trademark Office program, the average pendency had been reduced to about 19 months. This current average pendency renders the patents by application date data shown for years subsequent to 1975 (i.e., 1976-1977 incomplete. The obvious reason for this is that a significant number of the applications filed in 1976 and 1977 were still pending. Since these applications had not, as yet, matured into patents, they were not reflected in the OTAF database at the time of the preparation of this publication.

It should be noted that only applications which ultimately matured into patents are reflected in the application date data ("patented applications"). Those applications which were filed but never issued (roughly 30% of total filings) are not included.

Methodology and Results:

For this study, application filing date and assignment information were used to prepare a series of graphs profiling patenting over time for the years 1965-1974.

Figure 2-1 compares U.S. patenting by grant date (offset two years) and patented application date. This figure reveals the spurious nature of much of the variation in grant date data, as well as the effect of the PTO backlog reduction program.

FIG. 2-1: U.S. PATENT GRANTS (TOTAL AND TO FOREIGN RESIDENTS) DISTRIBUTED BY GRANT DATE AND APPLICATION DATE (OFFSET TWO YEARS)

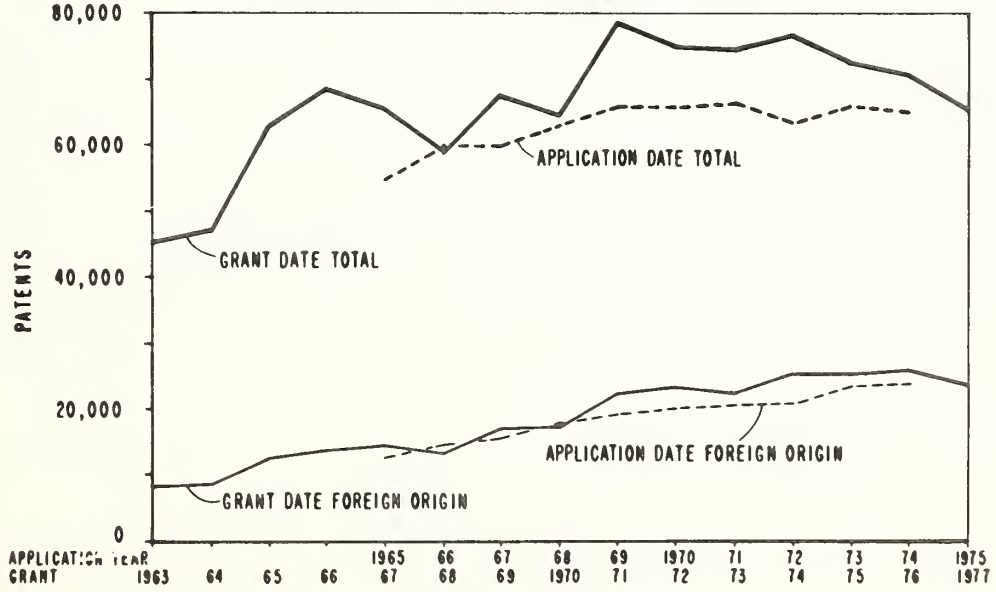
80,000
60,000
40,000
20,000
0
PATENTS
APPLICATION DATE TOTAL
GRANT DATE TOTAL
APPLICATION DATE FOREIGN ORIGIN
GRANT DATE FOREIGN ORIGIN
APPLICATION YEAR 1965 66 67 68 69 1970 71 72 73 74 1975
GRANT 1963 64 65 66 67 68 69 1970 71 72 73 74 75 76 1977

Figure 2-1 also reflects the increasing share of U.S. patents granted to foreign resident inventors, a trend previously mentioned as being familiar to readers of past OTAF reports. Over the last 15 years there has been a fairly steady increase in the percentage of U.S. patented applications of foreign origin, up from 19% in 1963 to a high of 35% in 1975.

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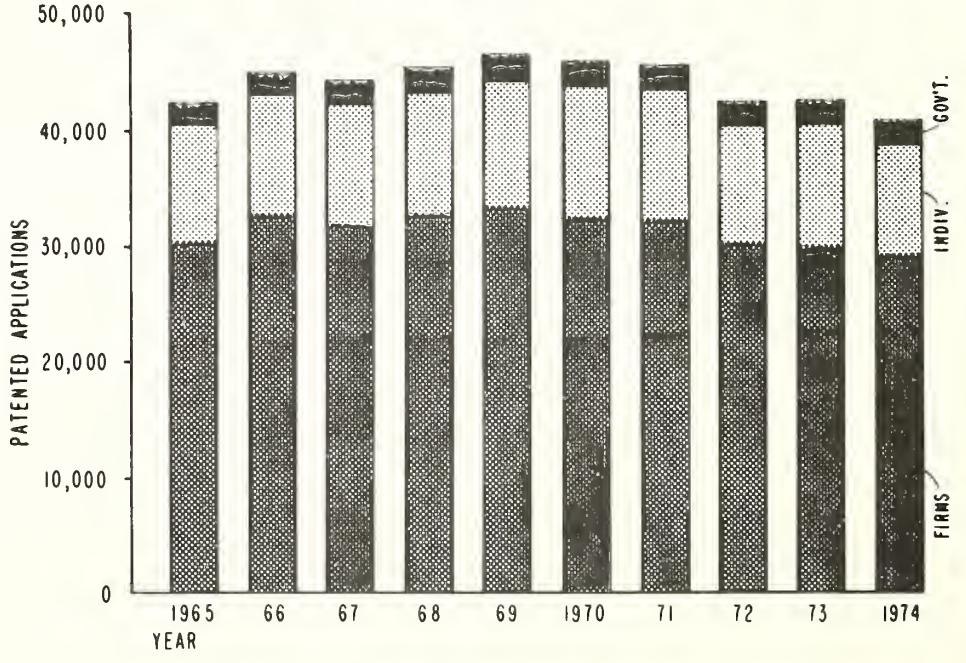
Recent trends in domestic origin patent activity are shown by major assignment category -- government, individual, and firm* -- patenting in Fig. 2-2. Given for each year and each category are the number of patented applications filed. The figure shows:

- a roughly "stagnant" domestic patenting pattern over the time period shown. Patenting in the last three years was lower than the preceeding three years (1969-1971) and approximately the same as 1965-1967. Fluctations between any two years was less than 10% and followed no consistent trend (e.g. 1973 was greater than either 1972 or 1974).

- the activity of major categories generally mirrored the overall activity of which they are a part. No significant change in the percentage of patents granted to individuals or assigned to government or firms was found.

FIG. 2-2: DOMESTIC ORIGIN U.S. PATENTED APPLICATION FILINGS 1965-1974



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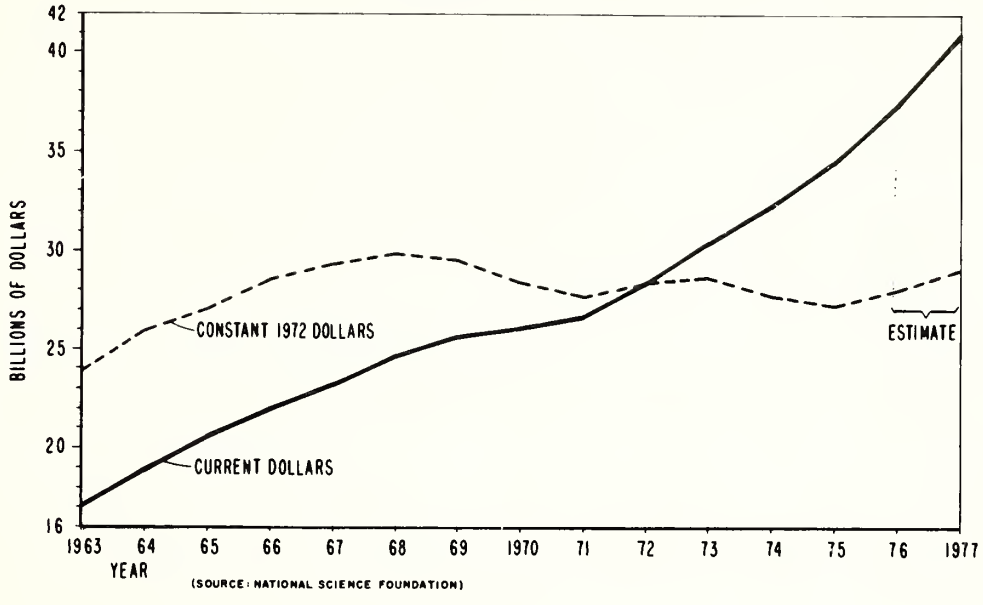
*Included in this category are non-corporate entities such as universities. However, the patenting of these entities is insignificant in comparison to that of corporations.

Given the stagnant nature of domestic patenting in the decade spanning the mid-sixties and seventies, the question of its interpretation remains. Does it reflect stagnation in innovative activity, a decline in the use of the patent system, or something else? A look at R&D expenditures (see Figure 2-3), an input to the innovative process leading to patents, suggests that the stagnation in patenting activity reflects a stagnation in innovative activity. Total R&D expenditures in constant dollars (corrected for inflation), over the period 1963-1977, is fairly constant, i.e., "stagnant", with yearly fluctuations (increases and decreases) similar to that observed for the patenting trends of Figure 2-2.

FIG. 2-3 · TOTAL R&D SPENDING IN THE U.S. (CURRENT AND CONSTANT DOLLARS)
1963-1977

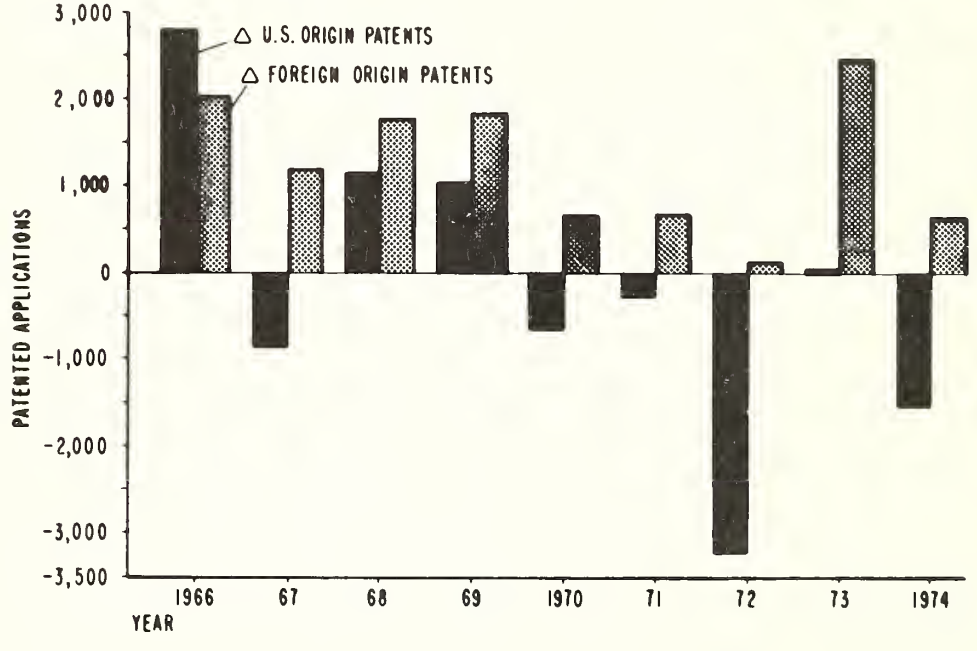


The comparison of patent data with total R&D expenditure in Figure 2-3 must be realized to be imperfect, partly because R&D has many components, only some of which are patent oriented. For example, Research includes a good deal of basic research which is not patent oriented. Also, in this era of environmental awareness and concern for product safety, there may be an increasing amount of Development expenditures for activities that are defensive in nature which often do not result in patents. Examples include pollution control expenditures and more extensive product testing activities. A more detailed analysis, needed to determine if reduced patenting levels are the result of reduced technological activity, would involve a comparison of patenting trends with only those R&D expenditures leading to new processes or products.

Short Term Trends - Total Patenting:

As an aid in examination of short-term trends, Figure 2-4 shows the yearly changes in patented applications for domestic and foreign origin patents. The years 1966-69 show a generally increasing trend in U. S. origin patenting and 1970-74 a decreasing trend, while foreign patenting shows increases across the board. The incomplete data for 1975 (not shown on Fig. 2-4), indicate a significant decrease in foreign origin patented applications filed that year.

FIG. 2-4: YEARLY INCREASE OR DECREASE IN U.S. AND FOREIGN ORIGIN PATENTED APPLICATION FILINGS 1966-1974



Short Term Trends - Domestic Origin Patenting:

As previously noted, the 10 year period from 1965 to 1974 shows no dramatic trends in domestic patenting: A slight increase to 1970, and decreases to 1974; overall, a 3.4% decrease from 1965 to 1974. Furthermore, over this period, the breakdown into corporate, government, and individually owned patents shows no perceptable changes. The proportions are relatively stable. (See Fig 2-2).

Figure 2-5 shows the yearly changes in patented applications for these same groups. Corporations show, after 1969, a fairly consistent, decreasing trend. Government patenting* seems to fluctuate without much pattern, though there are generally small increases in the earlier years and decreases in the later years (except 1974). Similarly there seems to be no well defined trend for individual patenting.**

The net decrease of U.S. origin organizational patenting over the period 1969-1974 is 4,114 (33,375 to 29,261). How much of this decline is a result of reduced R&D activity specifically directed to new product development or to a decline in the use of the patent system remains to be elucidated.

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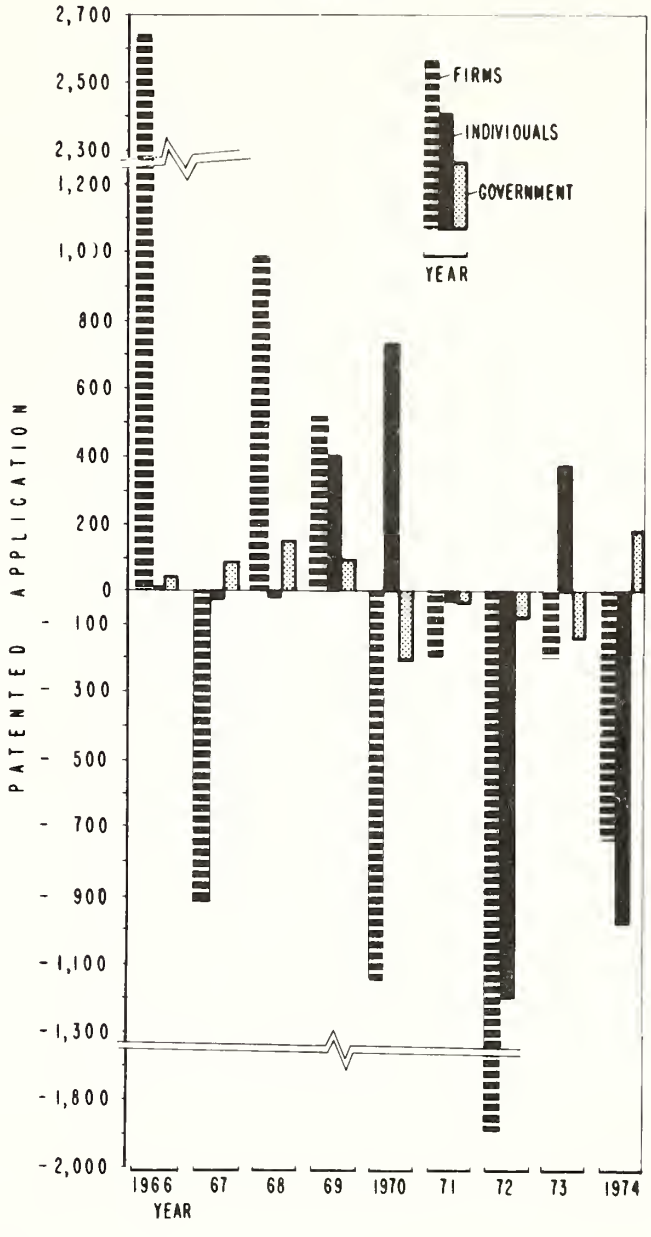
FIG. 2-5: YEARLY CHANGE IN DOMESTIC PATENTING BY U.S. FIRMS, INDIVIDUALS AND GOVERNMENT 1966-1974



More on organizational patenting trends:

A small group of large organizations (mostly corporations, but including some Government agencies) receives substantial numbers of U.S. patents. This is illustrated in Figure 2-6. Shown is the distribution of organizational patenting from 1969 - 1977. During that period the U.S. granted

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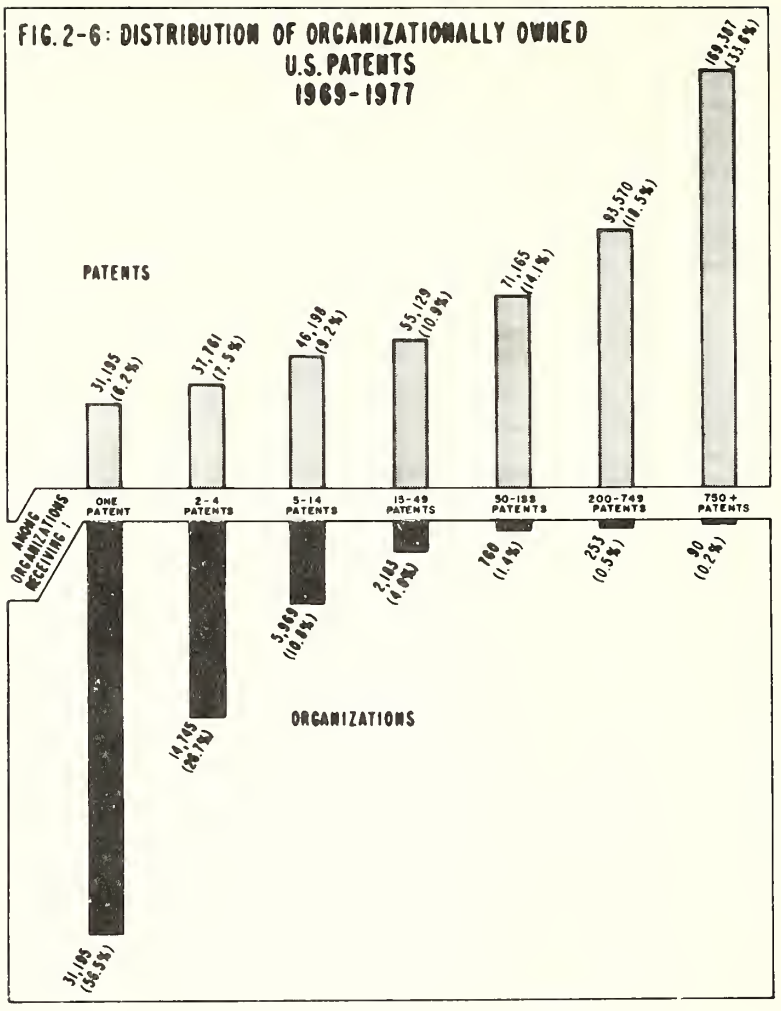
*OTAF statistics on Government patenting include only those patents assigned to government agencies at time of issue of the patent grant.
**Patenting which, at time of issue, has not been assigned to an organization (e.g., corporation, government agency) is considered individual patenting. It includes patents unassigned at time of issue and patents assigned, at time of issue, to persons other than the inventor (s).



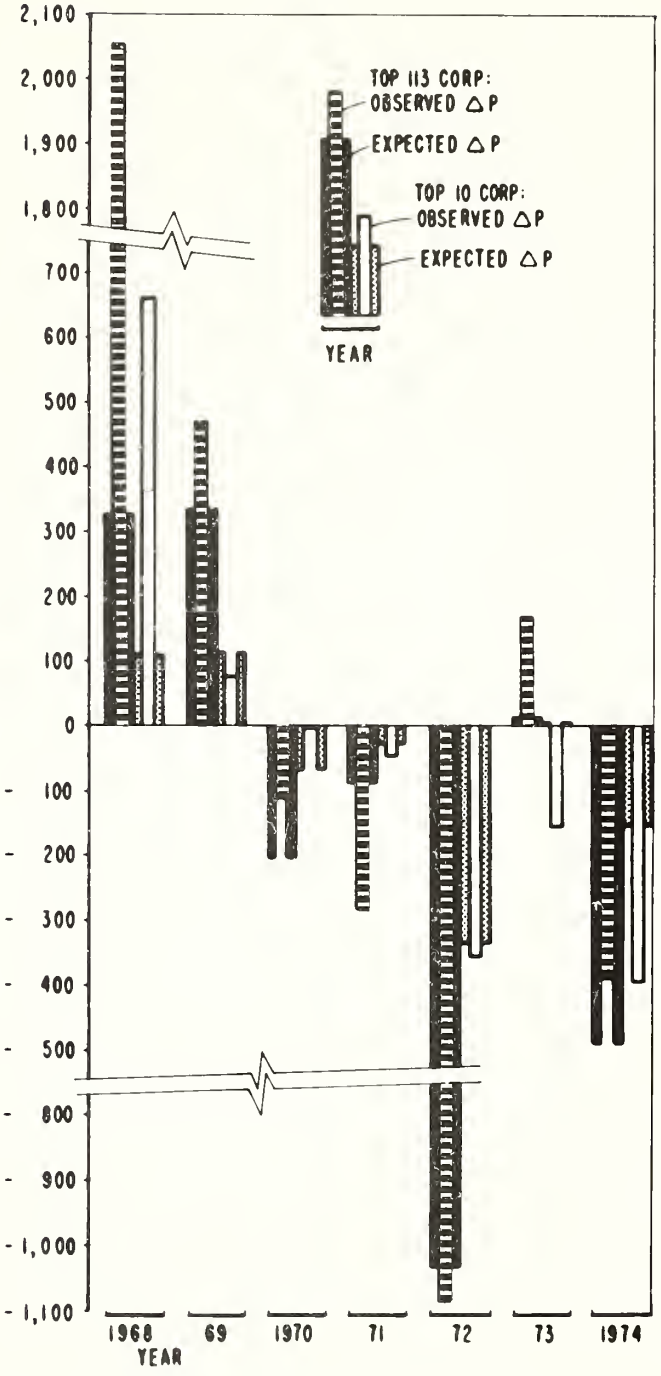
over 643,000 patents. Of these, almost 505,000 (nearly 80%) were assigned at time of issue to over 55,000 distinct U.S. and foreign organizations. Of these 55,000 organizations, about 32,500 (roughly 60%) are located in the U.S.

As Figure 2-6 shows, there are many firms which receive only one or a few patents, indicating a broad base of Patent System use. On the other end of the scale, however, there are a few firms which receive many patents. For example, the 343 organizations (247 of them U.S. based) which received 200 or more patents during the period, represent less than seven tenths of one percent of the total number of patenting organizations. Yet, that 0.7% was responsible for over 52% of the 1969-77 organizational patenting (41% of total patenting). The 247 U.S. organizations in this group accounted for most of the patents. These U.S. organizations produced 33% of all U.S. patents granted during the period and were responsible for nearly 50% of all domestic patenting.

Obviously, with a small number of large firms responsible for such a significant portion of total domestic U.S. patenting, any change in the propensity to patent (i.e., the use of the Patent System) by just a few of them could have an inordinate effect on total domestic patenting. Significant

changes in patenting of other groups (government, individuals, etc.) may well be masked by changes in patenting patterns of large organizations. The effect of large firm patenting on patent trends was examined by looking at patenting patterns of the most patent active corporations. Figure 2-7 exhibits yearly changes in the filing of applications ultimately patented (patented applications) by the 113 most patent active U.S. corporations* and their subsidiaries. These corporations were responsible for 32% of all U.S. origin, patented applications filed between 1967 and 1974. Also shown are the changes in patent application filing for the top 10 corporations -- responsible for 10% of all U.S. origin patented applications filed. Contrasted with this is the change that would be expected if the yearly changes were distributed evenly across all users in proportion to their use levels. For example: Since the top 113 corporations do 32% of all domestic patenting, and if the decrease (or increase) in domestic patenting is uniformly distributed across all sources of U.S. origin patents, then those top corporations should account for about 32% of the change.

Fig. 2-7: Yearly Change In Patenting by the 113 Most Patent Active U.S. Corporations



What was found was that the changes were not uniformly distributed. In 1968, 1969 and 1973, the top 113 corporations accounted for a larger than expected share of the increase. In 1971 the top corporations showed a

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* A listing of the 113 corporations with their 1969-77 U.S. patenting of U.S. origin and foreign origin (including that of subsidiaries), distributed both by patent grant date and by patented application filing date, is given in Appendix A.

larger than expected decrease. However, in 1970 and 1974 a less than expected decrease was apparent. Interestingly, the top 10 patenting corporations did not always exhibit the same behavior as the top 113 (of which they were, of course, a portion). Of particular interest are 1973 and 1974, when the top 10 experienced much larger decreases than would be expected under the hypothesis of constant distribution over time. This suggests that fluctuations in patenting levels are not always predominantly the result of changes in patenting by large corporations.

In Conclusion:

What then can be said about the patent trends examined? In our opinion, it can not be denied that each patent represents a increment of technological activity resulting in an invention. In the aggregate and for a given technology, patents therefore are an indicator of the level of technological activity taking place. Whether they are a gross indicator (because other factors need to be considered) or a time measure of technological activity must be determined on a case by case basis.

In many instances an attempt to draw definitive conclusions from patent trends alone, may be a gross oversimplication of complicated interactions involved in the innovation process and the economy. However, because patents are early evidence of invention and because patent data are readily available across the whole spectrum of technology, failure to consider patents as at a least part of a composite index for innovation trends, is to ignore a potentially important indicator of such trends.

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Independent Inventor Trends

At the end of the patenting spectrum opposite the corporate grants are the patents obtained by independent inventors, those working without institutional support. Unassigned patents (patents which, at time of issue, are not assigned to an organizational entity) have long been thought to indicate the inventive output of independent inventors. This Section examines the validity of this hypothesis.

At the beginning of this century, patents to individuals* constituted the bulk (over 80%) of all U.S. patents granted. However, as shown in Figure 2-8 on the following page, patenting by individuals experienced a continuous sharp decline until about the mid-1960's when it assumed a relatively steady state share of 19% of the U.S. patents granted -- 16% to U.S. residents.

Some have alleged that even this modest share of U.S. patents may be an overstated indicator of independent inventor patenting. The basis for this contention is the allegation that some significant number of corporations routinely do not file assignments prior to the issuance of a patent so as to

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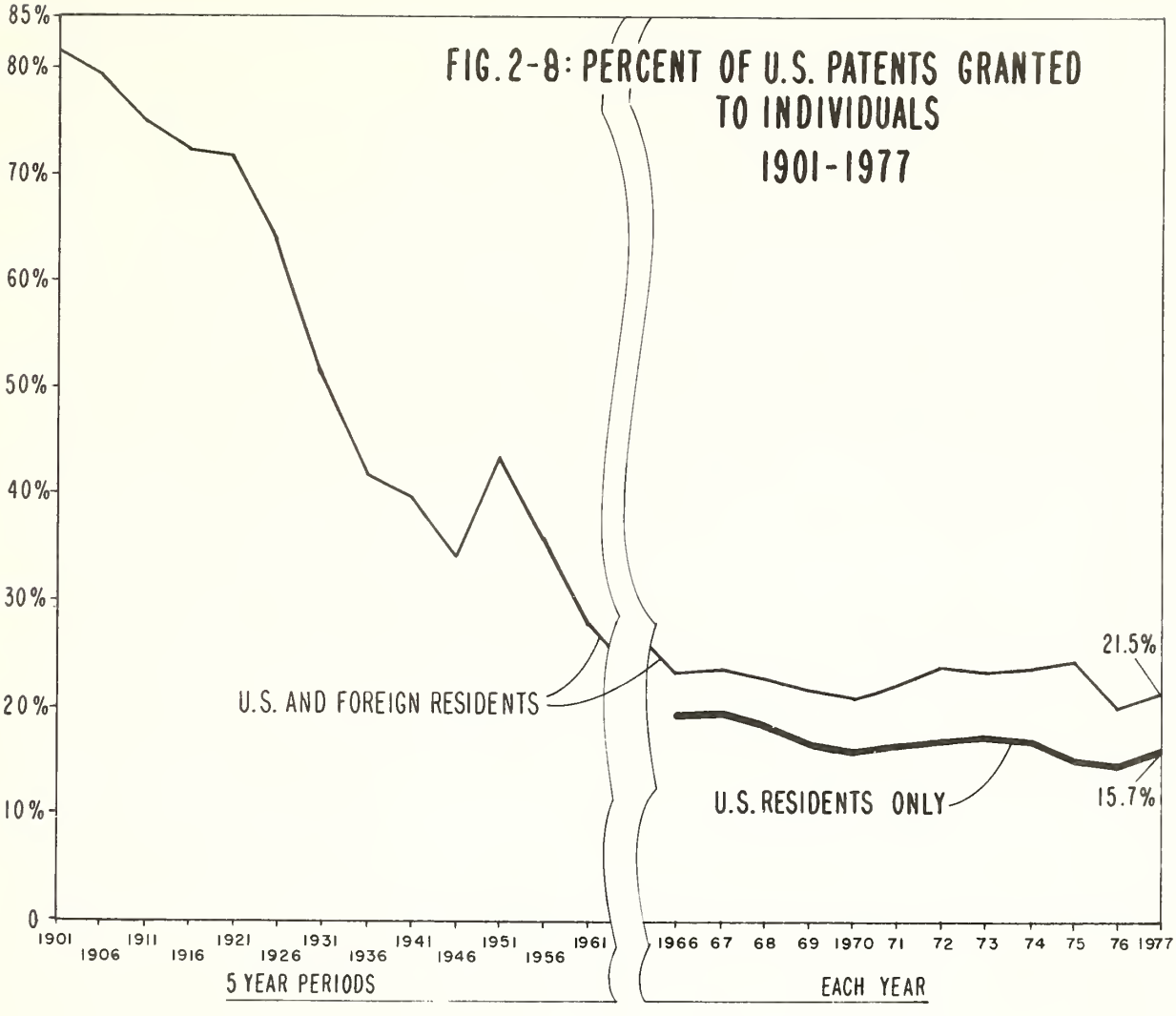
* These data include "non-organizational" patents, i.e., those unassigned at time of issue and those assigned to individuals at time of issue. The latter are few in number compared to the total in the category, e.g., 688 out of 17,477 in 1975, or less than 4%.



avoid having the corporation's name printed on the patent and, thereby to inhibit public knowledge of their ownership of the patent. If this allegation were true, the percentage of patents received by independent inventors in the U. S. might be far fewer than 16%. Such a discovery might have significant public policy implications.

What follows is a study undertaken to determine the extent to which patents unassigned at time of issue (called "unassigned patents" in the balance of this Section) are subsequently assigned. The purpose of the study was to determine the extent to which "unassigned patents" might be the result of organizational support rather than independent inventor activity.

Methodology:

The study was simple in design. A random sample of the roughly 14,000 unassigned U. S. patents that issued in a given year were examined to see how many became assigned patents after their issue date. Assignments of patent grants, by law, must be recorded in the Patent and Trademark Office to protect the rights of the assignee (35USC§261). Consequently, the information necessary for this project was readily available. For each patent in the sample which was assigned after issue,

the assignee, time from issue to assignment, patent number, technology, and origin (U.S. or foreign) were recorded. The latter was ascertained from the address of the first inventor.

"Unassigned patents" issuing in 1970 were chosen for initial study for two reasons. First, they were felt to be sufficiently recent to give results indicative of current assignment practices. Second, sufficient lapse time from patent issue date exists for these patents (7 years), that most assignments would be recorded. "Unassigned patents" considered possibly corporate inspired are taken to be those assigned to a corporation within six months of issue. "Unassigned patents" which were assigned more than 6 months after issue are considered to be the product of independent inventor activity. Of course, patents to independent inventors could be assigned within the first 6 months from issue date; however, in most cases, because of the time required to identify a buyer and sell the patented invention, assignment of independent inventor patents probably would not take place until a much later date.

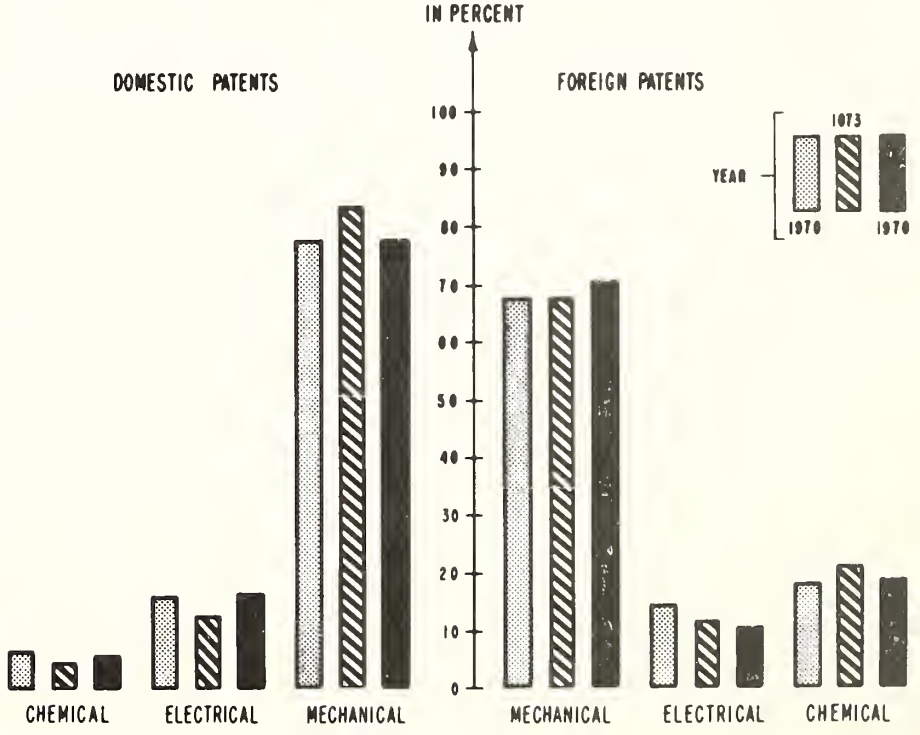
"Unassigned patents" issuing in 1973 and 1976 were also studied.

The random sample for each year consisted of 138 U.S. origin patents and the same number of foreign origin patents, unassigned at time of issue. The number selected was sufficient to provide a precision of at least 5% in the results at a 95% confidence level.

Results:

A review of the distribution by discipline of unassigned patents in the study samples is presented in Figure 2 - 9. For both domestic and foreign origin sample patents, it was found that the overwhelming majority pertained

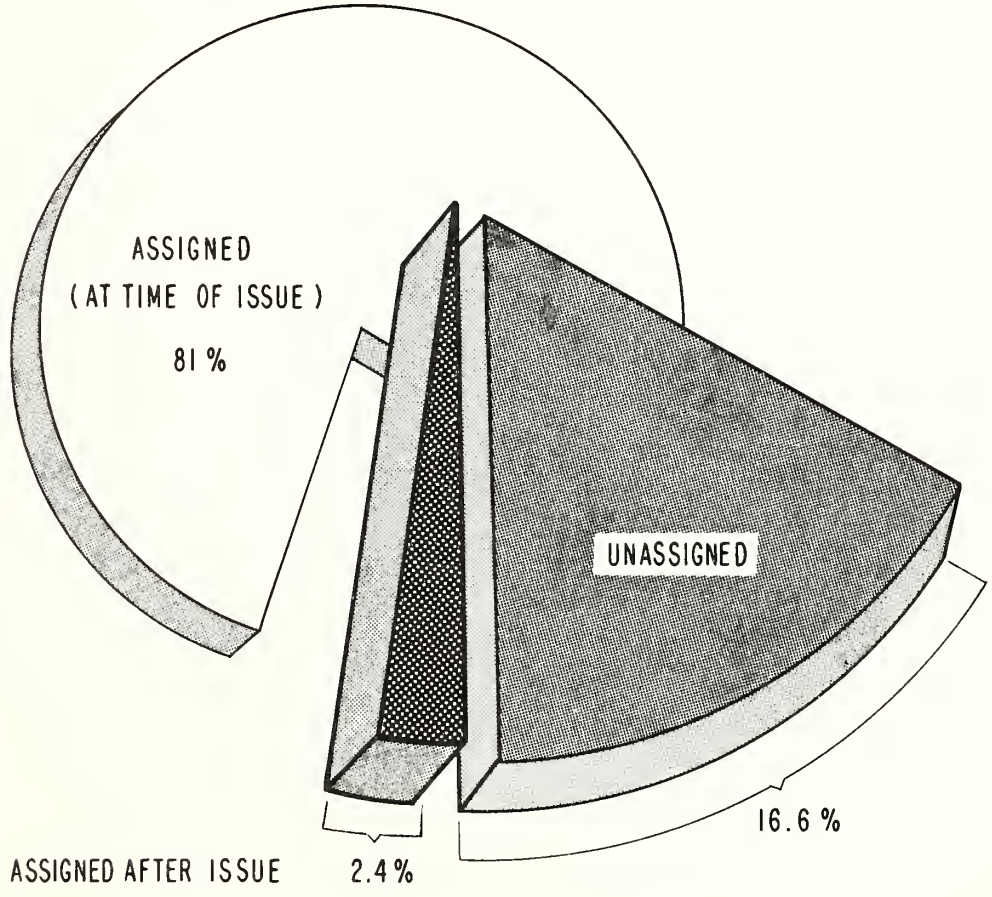
FIG. 2-9: DISTRIBUTION BY DISCIPLINE OF UNASSIGNED PATENTS IN STUDY SAMPLES



to mechanical technologies. For domestic patents, electrical was the discipline of next importance with chemical being least important. For foreign origin patents a reversal of the importance of electrical and mechanical patents was noted. Among years, no significant trend was noted. Approximately the same percentage of mechanical, electrical and chemical patents were found in each sample year.

The assignment distribution of all 1970 patents regardless of origin is shown in Fig. 2-10. Fully 81% of the patents granted that year were assigned prior to issuence of the patent grant. Most of these are recorded on the face of the patent grant.* The remaining patent grants (19%) were unassigned at time of issue. Of these, the results of this study indicate 2.4% of all patents (13% of those unassigned) were subsequently assigned within about 7 years of the issue date. Because a patent grant can be assigned at any time during its 17 year life-span, this 2.4% figure is conservative. However, since most patents having commercial value will be sold relatively early in the life of the patent grant, this study, involving 7 years of data or 40% of a patent's life-span, most likely captures the bulk of the assignments that are recorded after issue.

FIG. 2-10: ASSIGNMENT DISTRIBUTION OF 1970 U.S. PATENTS



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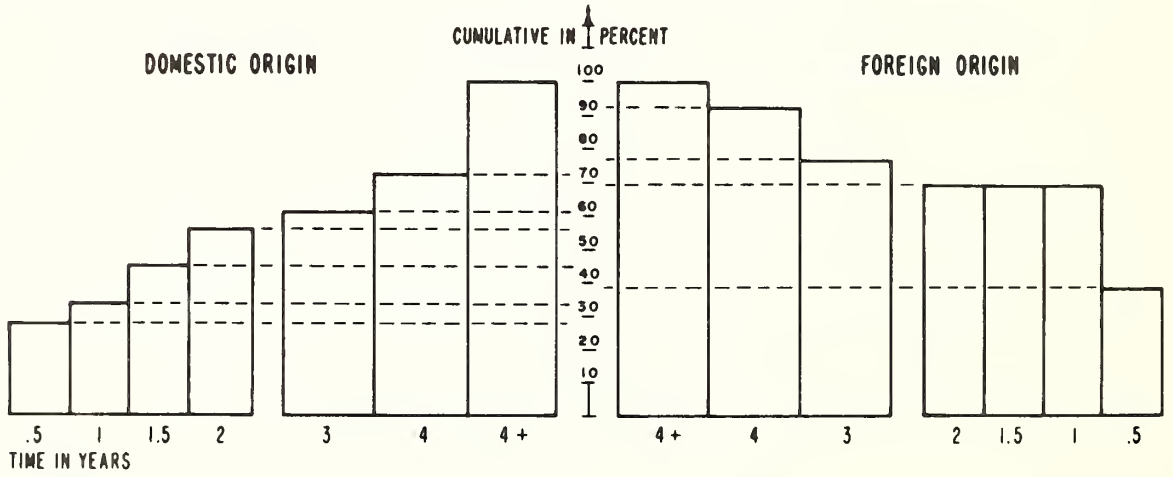
* Because patents are often printed weeks in advance of the grant date, a few patents, assigned near the date of the patent grant, issue without the assignment being printed on the face of the patent document.

Of the relatively small number of "unassigned patents" that are subsequently assigned (2.4%), the question remains how many of these are corporate inspired patents whose assignment was delayed; and how many are the efforts of independent inventors who assign their patent rights after issue? This information can be discerned from an analysis of time to assignment of "unassigned patents". It is reasonable to assume that corporate inspired "unassigned patents" would be assigned soon after issue (within 6 months) because of a company's vested interest in the invention and its desire to secure patent rights quickly. Those filed after this period are more likely to be independent inventor patents which are assigned after issue.

A summary of time to first assignment of both U.S. and foreign origin 1970 "unassigned patents" subsequently assigned (within the first 7 years of their issue date) is given in Figure 2-11. Only 27.8% of U.S. origin and 38.5% of foreign origin patents that are assigned within 7 years of issue, are assigned within 6 months of issue date. Expressing this as a percentage of all 1970 patents, only 0.7% appear to be corporate inspired patents, i.e., assigned within 6 months of issue. The remainder, 1.7%, assigned 6 months -7 years after issue, appear to be individual inventor patents sold after issue.

FIG. 2-11: **PATENTS FIRST ASSIGNED AFTER ISSUE**
TIME TO FIRST ASSIGNMENT



The results obtained for 1973 and 1976 were of the same order of magnitude as those obtained for the 1970 sample. The results for all years, expressed as the number and percent of all patents issuing in a given year, are presented in Table I.

TABLE I

Extent of Assignment After Issue
Of Patents Unassigned At Issue
(1970, 1973, 1976)

	1970		1973		1976	
Time to Assignment from issue date. (yr.)	No. of Patents	% of All Patents	No. of Patents	% of All Patents	No. of Patents	% of All Patents
0.0-0.5	453	0.7	228	0.3	144	0.2
0.5-1.0	272	0.4	114	0.2	144	0.2
1.0-1.5	91	0.1	57	0.1	96	0.1
1.5-2.0	91	0.1	57	0.1	Not available	
2.0-3.0	136	0.2	57	0.1	Not available	
3.0-4.0	181	0.3	Not available		Not available	
4.0-7.0	272	0.4	Not available		Not available	
Total Patents Granted By Year	64,427		64,139		70,236	

While complete information for 1973 and 1976 was not available (lapse time for these years was 4 years and 1 year, respectively), the data for assignments within the first six months are comparable between years. For 1973 and 1976 about half as many patents were found to be assigned as was observed for 1970.

§ §

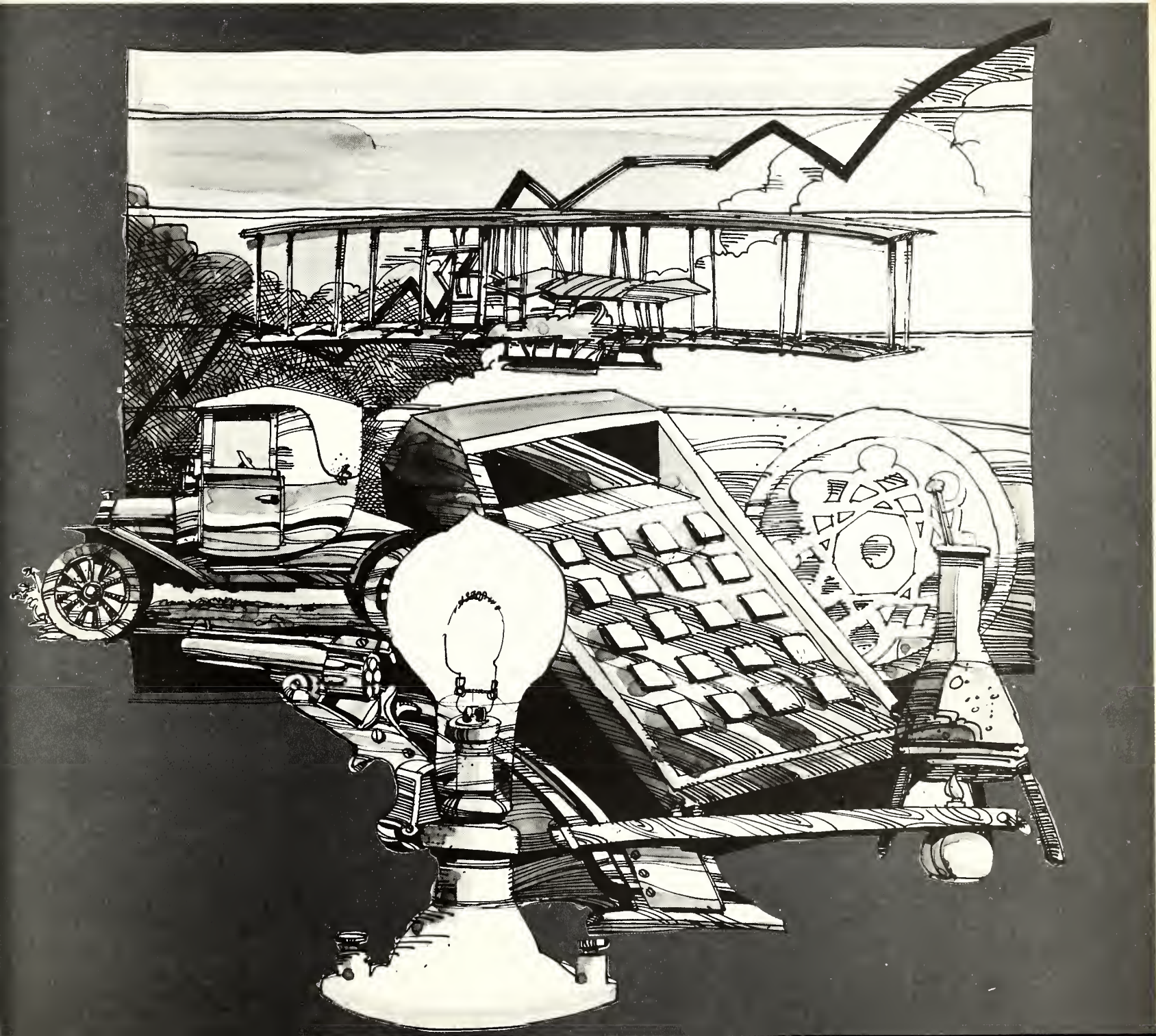
In Conclusion:

The hypothesis which states that "unassigned patents" indicate the inventive output of independent inventors seems to have been confirmed by this study. No evidence was found to support the position that the bulk or even a significant portion of these patents are really corporate inspired patents which are assigned after issue.

TECHNOLOGY ASSESSMENT & FORECAST

III

FERROUS METAL



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Introduction

In this section, patent activity in Ferrous Metal technology is examined. The study answers, from a patent perspective, and for a sample technology, the questions; who, what, where and why. Its purpose is to show that much of the character of a technology -- information that is of great importance and benefit -- can be readily ascertained from patents. In doing this, the section makes use of foreign, corporate, and technological information found in U.S. patents, and follows a format first presented in OTAF's Seventh Report* and continued in the Eighth Report**.

Why is the characterization of a technology of such importance? If for a given technology it can be determined what is being done, who is doing it, why it is being done and where, then much can be said about the present status of the technology, the direction it seems to be going and the potential for growth. Such information is valuable to decision makers, analysts, and forecasters in both the public and private sector.

A review of patents is essential to any in-depth study which attempts to characterize the level of development of a technology. Recent studies, including one published by OTAF ***, have found that the overwhelming majority of technology disclosed in the patent literature is not disclosed in the non-patent literature.

Background

Ferrous Metal technology was selected to exemplify the use of patents as an informational resource for several reasons. First, it is a technology and industry of great importance to the nation. In 1977, the U.S. produced 113 million tons of steel,**** the most important of the ferrous alloys, for use in products ranging from structural materials to eating utensils. Steel products are utilized to such an extent that we can describe the technological age of the twentieth century as the steel age. Without products such as steel, we could not live as we do today.

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* Seventh Report of the Office of Technology Assessment and Forecast, March 1977, page 96, "Computer Memory Components".

** Eighth Report of the Office of Technology Assessment and Forecast, December 1977, page 45, "Geophysical Exploration for Hydrocarbons".

*** IBID., page 23

**** Iron & Steel Engineer, August 1978, page 61.

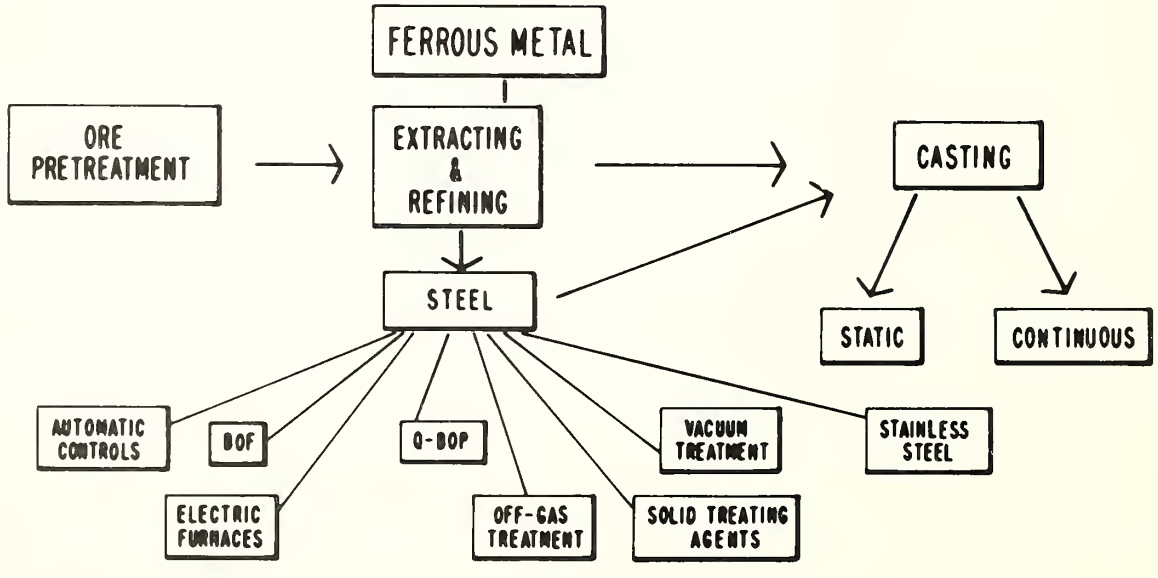
Second, the technology is of interest because, in the U.S., the Ferrous Metal industry is weakened by the importation of large amounts of less expensive ferrous metal products from innovative foreign competitors. In 1976 imports accounted for 14% of all ferrous metal products used in this country, up from 12% in 1967. The declining stature of the U.S. Steel Industry is reflected in the declining U.S. share of total raw steel production. In 1967 the U.S. produced 23% of the world's raw steel, in 1976 this decreased to 17%*. A patent analysis of the ferrous metal industry would be an aid to the identification of foreign innovations in this technology, providing information about their nature and point of origin which may be useful in forecasting future trends in import activity.

Third, a review of the patenting in this technology appears to be particularly appropriate at this time because industry and government are aware of the need for innovation in the ferrous metal industry and are searching actively for ways to stimulate innovation. This report, in characterizing the state of recent innovations in Ferrous Metal technology, as documented by U.S. patents, seeks to obtain a better understanding of the current state of development of the technology and hence a knowledge of what is needed in the way of innovation.

Scope

For the purpose of this study Ferrous Metal technology is defined as any process or apparatus used to produce iron or iron containing metal, and any iron containing primary metal product. The principal elements of the technology which will be discussed are outlined in Figure 3-1.

FIG. 3-1: COMPONENTS OF FERROUS METAL TECHNOLOGY



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* American Iron and Steel Institute, Annual Statistical Report (1976) page 8.

The study covers ferrous metal production from processing of the ore (e.g., beneficiating or agglomerating) through reduction and refining to the casting of primary products (blooms, ingots and the like). Excluded from this report are technological areas on both ends of this production scheme. For example, at the beginning, the actual mining of the iron ore is not included. After casting, further treatment (rolling, heat treatment etc.) leading to secondary or finished products also is not included.

Extracting and Refining, and Casting are further broken down into their principal components. For the former, steel is reviewed separately because of its importance and in turn is broken down into a number of specific technologies, some examples of which are shown in Figure 3-1. Casting is divided into two specific technologies, static and continous casting methods.

Analysis Procedure

The first step in a patent analysis is to define the area of interest in terms of subclasses, the smallest units of the U.S. patent classification (USPC) system.* Once this is accomplished, patents in pertinent subclasses can be easily identified and patent activity analyzed through the use of OTAF's computerized data base.

In building a concordance between a technological area and the USPC system, three situations are often encountered. The subclass identified may be entirely, substantially or only partially pertinent. The first situation is the ideal one and presents no problems. The second and third situations pertain to the identification of subclasses that are not technologically pure, i.e., they contain patents not pertinent to the subject area being investigated.

The latter situations were handled in the following way: subclasses deemed substantially pertinent (i.e., about 90% or more of the patents are relevant) were considered in their entirety. While this results in the inclusion of some non-relevant patents, their relative numbers were such as not to materially affect the statistics. Subclasses that were partially relevant were manually searched to identify pertinent patents.

Relevant classifications and patents were identified through use of the Patent Classification Manual and in consultation with patent examiners working in the technology. The output of this effort was used to generate standard OTAF technology profile reports**for each area. From these the statistical patent information was extracted and used as described on the following page.

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* The U.S. patent classification system is composed of approximately 350 major classes which are further subdivided into about 100,000 subclasses.
** Excerpts from a sample of this type of report are in Appendix C.

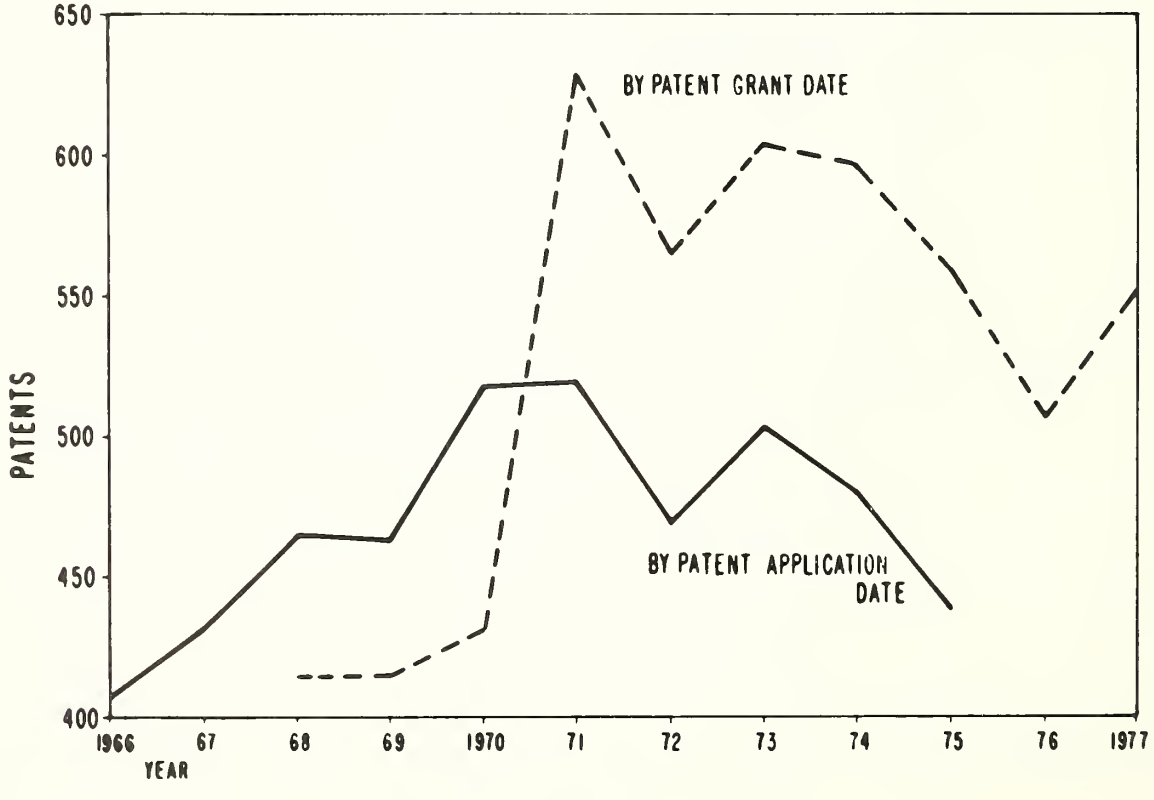
Patent Activity Data-

January 1968-December 1977 patent activity by year was tabulated both by patent grant date and by the application filing date* of these patents.

Patents distributed by application filing date are referred to as "patented applications" in this study. For the most part, the profiles which follow utilize this patented application data because the application filing date of a patent is a more accurate reflection of when the technology was developed.

Distributing 1968-1977 patents on an application date basis provides essentially complete data on those applications, which ultimately became patents, filed each year from 1966 through 1975. This is the case because there is a delay between the filing of a patent application and its subsequent issuance as a patent. The length of this delay (i.e., the "pendency" of an application) is determined by many factors, including Patent and Trademark Office workload, budget and man-power levels, patent printing schedules, etc. Present average pendency is about 19 months; but in 1968 it was over 2 years. Thus, most applications filed in 1966 did not issue as patents until 1968 or later.

FIG. 3-2: U.S. PATENT ACTIVITY IN FERROUS METAL DISTRIBUTED BY GRANT DATE AND APPLICATION DATE



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* Application filing date information is available for all patents issuing since January 1967. For this study, patent activity was limited to the decade 1968-1977.

The implications of the use of patented application data versus patent grant data can best be seen by reference to actual data. In Figure 3-2, patents in Ferrous Metal are given both by patent grant date and patent application date. The dotted line represents patents granted from 1968-1977 distributed by grant date. The solid line represents patents granted from 1967-1975 distributed according to the date of application for those patents. For the data plotted by application date, a "smoothing" of the trend-line is evident because these data are not influenced by Patent and Trademark Office examining practices. Also illustrated is the fact that most patents granted in 1968 were actually filed in 1966 and 1967 whereas, on the other end, most patents granted in 1976 and 1977 were filed in 1974 and 1975. Applications for patents filed in 1976 and 1977, for the most part, were still pending when the data were extracted, giving incomplete information for these years.

Assignment Data-

Most patents at the time of issue are assigned to corporations or other organizations. These assignments are printed on the patent document, and, since 1969, have been captured on a computerized data base. In the interim about 50,000 different organizations have been recorded as assignees for roughly half a million patents. Such information is of obvious interest in determining who owns what in a given technology.

For this report, the corporate owned patents in the technology, which issued between January 1969 and December 1977, were extracted and tabulated by assignee and year. In the three year period (1973-75), 85.6% of all Ferrous Metal patented applications were assigned at the time of issue to U.S. or foreign organizations (mostly corporations).

Foreign Activity Data-

For patents issuing in the area from 1968 through 1977, the country of origin (if other than U.S.) as indicated by the residence of the first inventor was recorded. Data were tabulated by year of application filing of these patents and reported as a percentage ("percent foreign") of the total patented applications filed in the area in each year. This information is useful in determining, in a technology, the position of the United States vis-a-vis foreign countries.

Content of This Section

The study is provided in two Parts:

Part I - Patent Activity Analysis

Part II - Review Of Selected Ferrous Metal Technologies

Part I begins with an analysis of the relative patenting in Ferrous Metal and its principle sub-areas: Ore Pretreatment, Extracting and Refining, and Casting. Also given are time series analyses, covering the period 1966-1975, analyzing patent activity in each of these areas. Included in these analyses are the U. S. origin vs. foreign origin patenting levels in each year.

Next, foreign activity is analyzed more fully. For Ferrous Metal broadly, the three principal sub-areas and for components of these sub-areas, the degree of foreign activity is expressed graphically as the three year average percent of all patented applications filed in a given area over two time periods, 1968-1970 and 1973-1975. In addition, the distribution of the foreign share of the technology among selected countries is shown.

Corporate patenting patterns are also reviewed. By way of example of the utility of this data, the leading assignees in five aspects of the ferrous metal industry are presented.

This part concludes with a comparison of statistics for Ferrous Metal technology with those for all technologies combined.

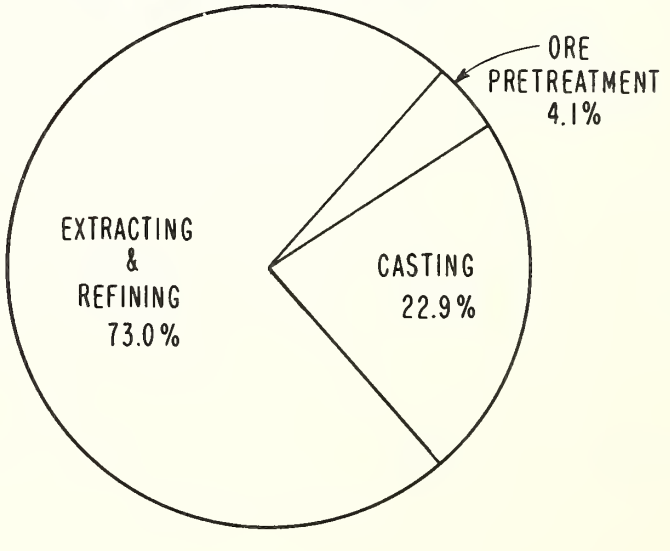
Part II consists of a series of reviews of the patenting in selected component areas of Ferrous Metal. These reviews present substantive information about developments in the technology and were prepared by patent examiners knowledgeable in the art.

PART I - PATENT ACTIVITY ANALYSIS

A. Patenting in Major Sub-areas of Ferrous Metal

A comparison of patent activity in the three major sub-areas of Ferrous Metals is shown in Figure 3-3.

FIG.3-3: FERROUS METAL PATENTING BY MAJOR SUB-AREA
3-YEAR AVERAGE (1973-1975)



Given for each area is the percentage of total patented applications filed in the period 1973-75. As might be expected the levels of patenting in the major components of Ferrous Metal are not equal. Extracting and Refining by far is the biggest area, having almost three-quarters of the patents issuing in Ferrous Metal. Casting is the next largest area and Ore Pretreatment is the smallest area with 4.1% of patented applications filed in this period.

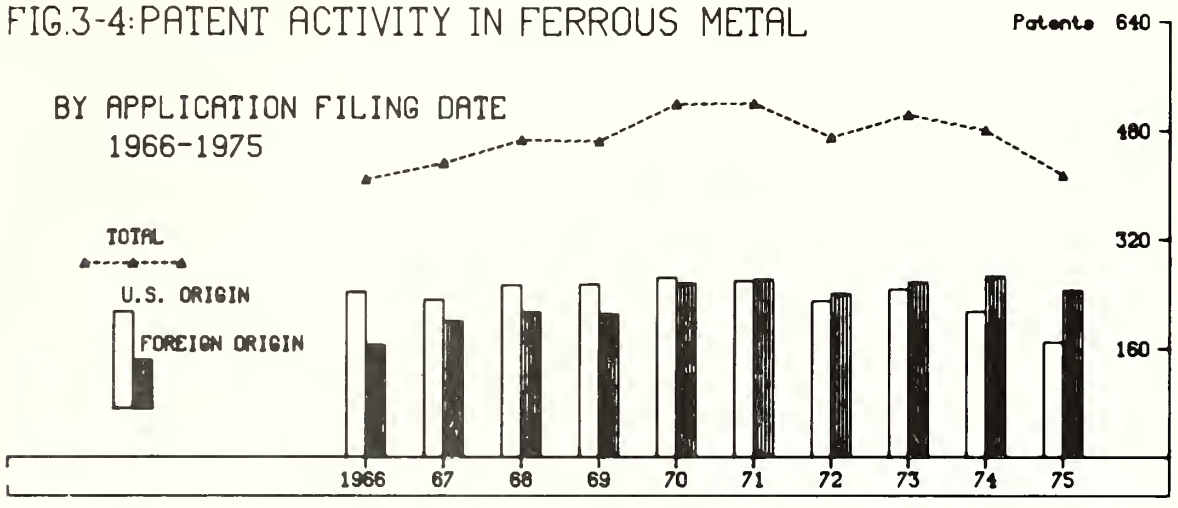


Figure 3-4 presents the yearly patent activity of Ferrous Metal technology. Shown is the number of patented applications filed, by year, from 1966-1975, and the U.S. vs. foreign activity* (bars) in each of these years. The graph shows that the number of patented applications reached a peak in the period 1970-71 (519) and has decreased slightly in succeeding years Also, a definite increase in foreign origin patenting is evident. In 1966, a minority of patented applications filed in the U.S. were of foreign origin, while in 1975 foreign resident inventors were responsible for a majority of patented applications filed in this technology.

The time series data for the three major sub-areas comprising Ferrous Metal are shown in Figures 3-5 to 3-7. A comparison of the scales of each of the figures further points out the relative size of the three areas. Approximately 20 patented applications per year are filed in Ore Pretreatment, about 350 per year in Extracting and Refining, and roughly 125 per year in Casting. In each area, the foreign activity increased over the period shown. The trend, in each case, was as dramatic as that observed above for the overall area. In 1966 the majority of U.S. patented applications filed in each major sub-area was of U.S. origin; in 1975, the majority was of foreign origin. This shows that foreign resident inventors are becoming more active in all of the principal aspects of this technology.

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*It should be reemphasized that "foreign activity" in this context, refers to U.S. patenting by foreign-resident inventors.

FIG.3-5: PATENT ACTIVITY IN ORE PRETREATMENT

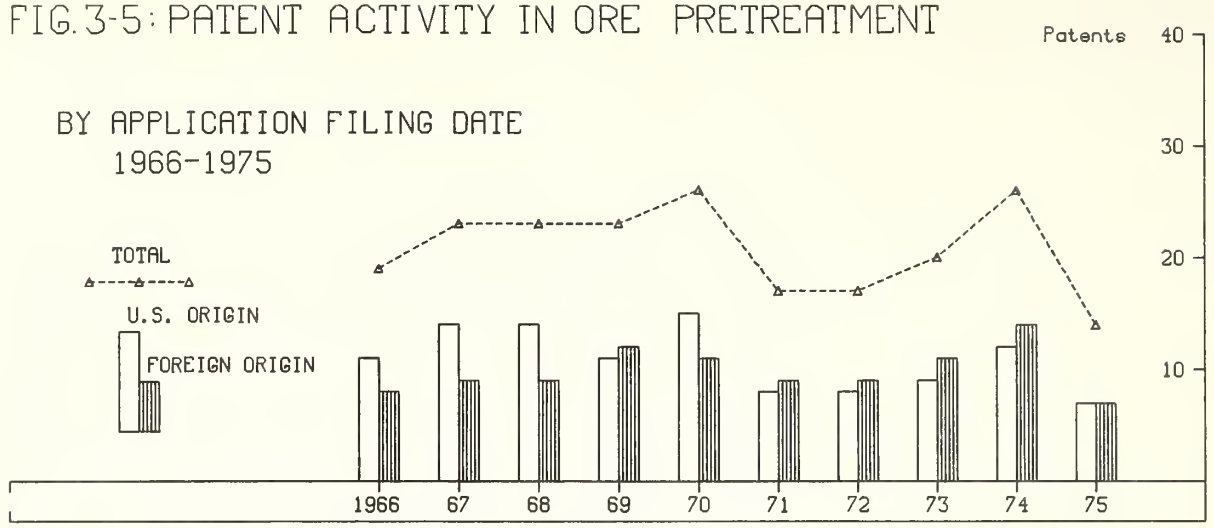


FIG.3-6: PATENT ACTIVITY IN EXTRACTING AND REFINING

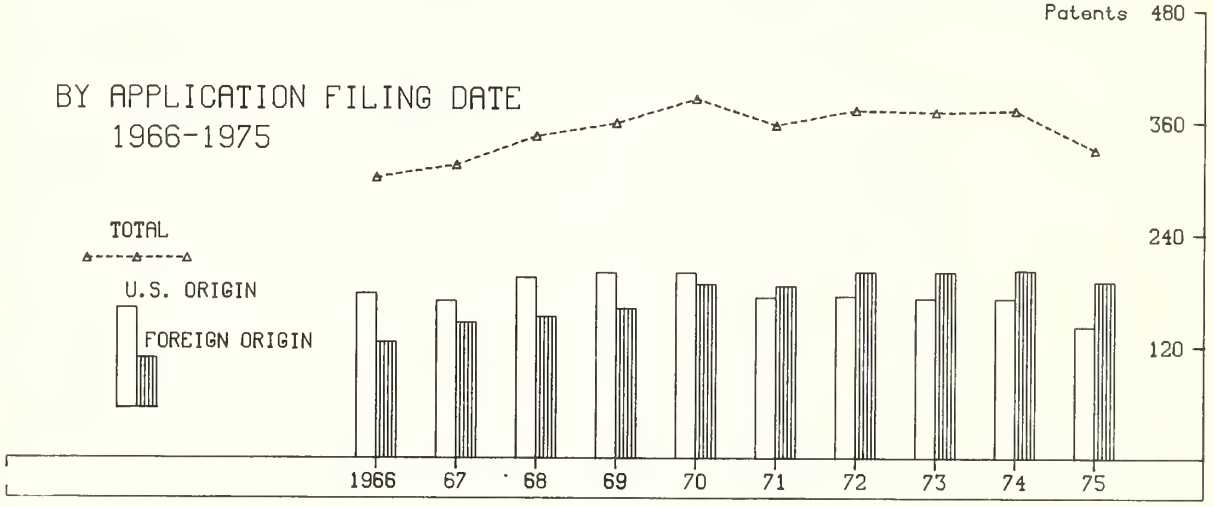
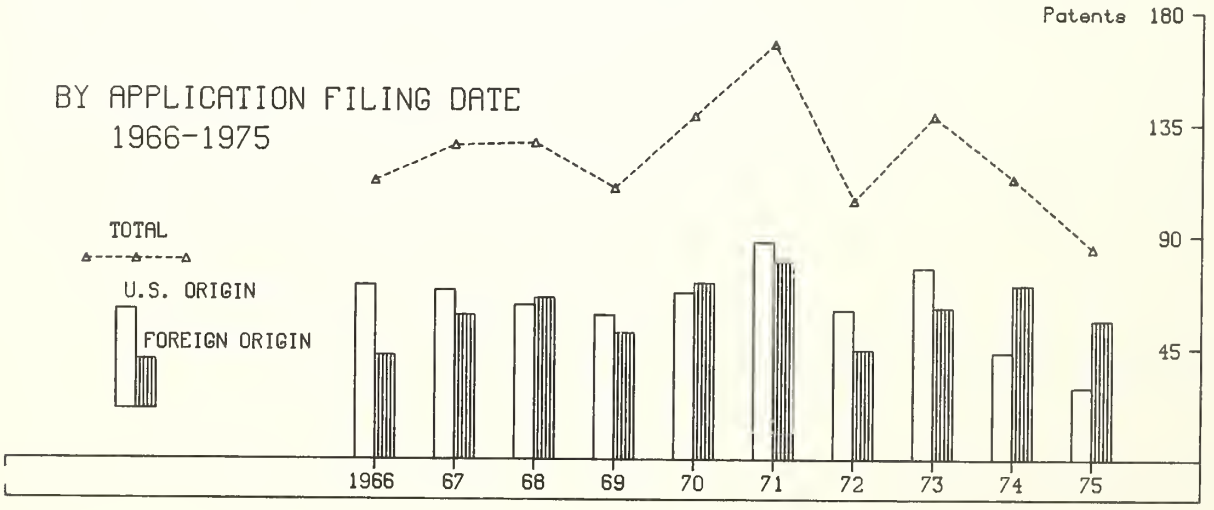


FIG.3-7: PATENT ACTIVITY IN CASTING



C. Foreign Patent Activity

This part of the section begins by looking at foreign activity at more disaggregated levels of the technology. In Figure 3-8 the percentage of Ferrous Metal patenting by foreign resident inventors at each level of the technology is shown for two time periods. The results are expressed as a three year average percent foreign of all patented applications in a given area for the periods 1968-1970 and 1973-1975, respectively.

The most notable trend is an increase in foreign activity in every area over the period investigated. For Ferrous Metal broadly, the increase was 8%, from 46.9% in 1968-70 to 55.0% in 1973-75. Comparable increases were noted in all areas except static casting where patents to foreign resident inventors almost doubled from 28.6% in 1968-70 to 52.3% in 1973-75.

The pie diagrams of Figure 3-9 show in Ferrous Metal and its three major sub-areas, the country breakdown of U.S. patenting by foreign inventors. In each analysis, it was found that Japan and the Federal Republic of Germany were among the leaders in the area regarding share of U.S. patents. Other countries where large amounts of innovation appear to be taking place are Sweden and Canada in Ore Pretreatment, and Austria and Switzerland in Casting.

By comparison, for all technologies combined (not shown), Japan is the leading foreign inventor country with 25.5%, the Federal Republic of Germany is a very close second (23.7%), United Kingdom is third (11.6%), and France is fourth (10.4%).

D. Corporate Patent Activity

What firms are obtaining patents in the area? For the most part patenting in the Ferrous Metal area is the result of the efforts of a relatively large number of firms. Approximately 1000 organizations (mostly corporations) received, in the period 1969-1977, about 4250 of the roughly 4850 patents that issued in the area. United States Steel, one of the largest steel companies, dominated all other corporations with 4.5% of all patents issuing in this period. This is almost 2.5 times as many as the next largest assignee, Vereinigte Oster Eisen-und Stahlwerke-Alpine Montan AG with 1.9% of the patenting. Eighty-eight organizations had 10 or more patents in this period.

A listing of the top 4 organizations receiving patents in five areas of Ferrous Metal is presented in Fig 3-10. For each organization the percentage of 1969-1977 patent granted in the area is given. Similarities and differences can be noted in these listings. For example, U.S. Steel Corp. leads three of the areas reviewed, but is not present among the top four assignees in two areas Ore Pretreatment and Static Casting.

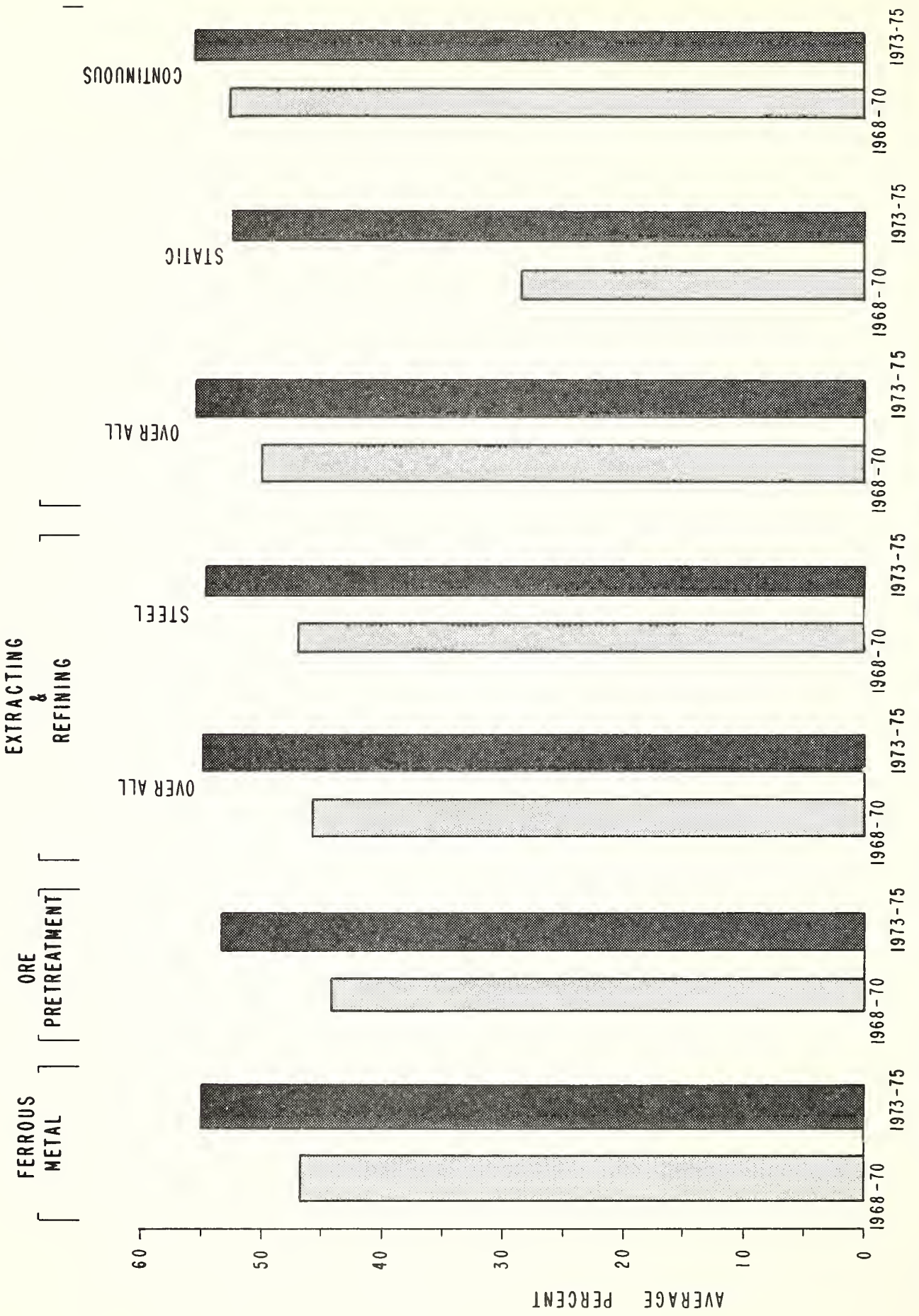
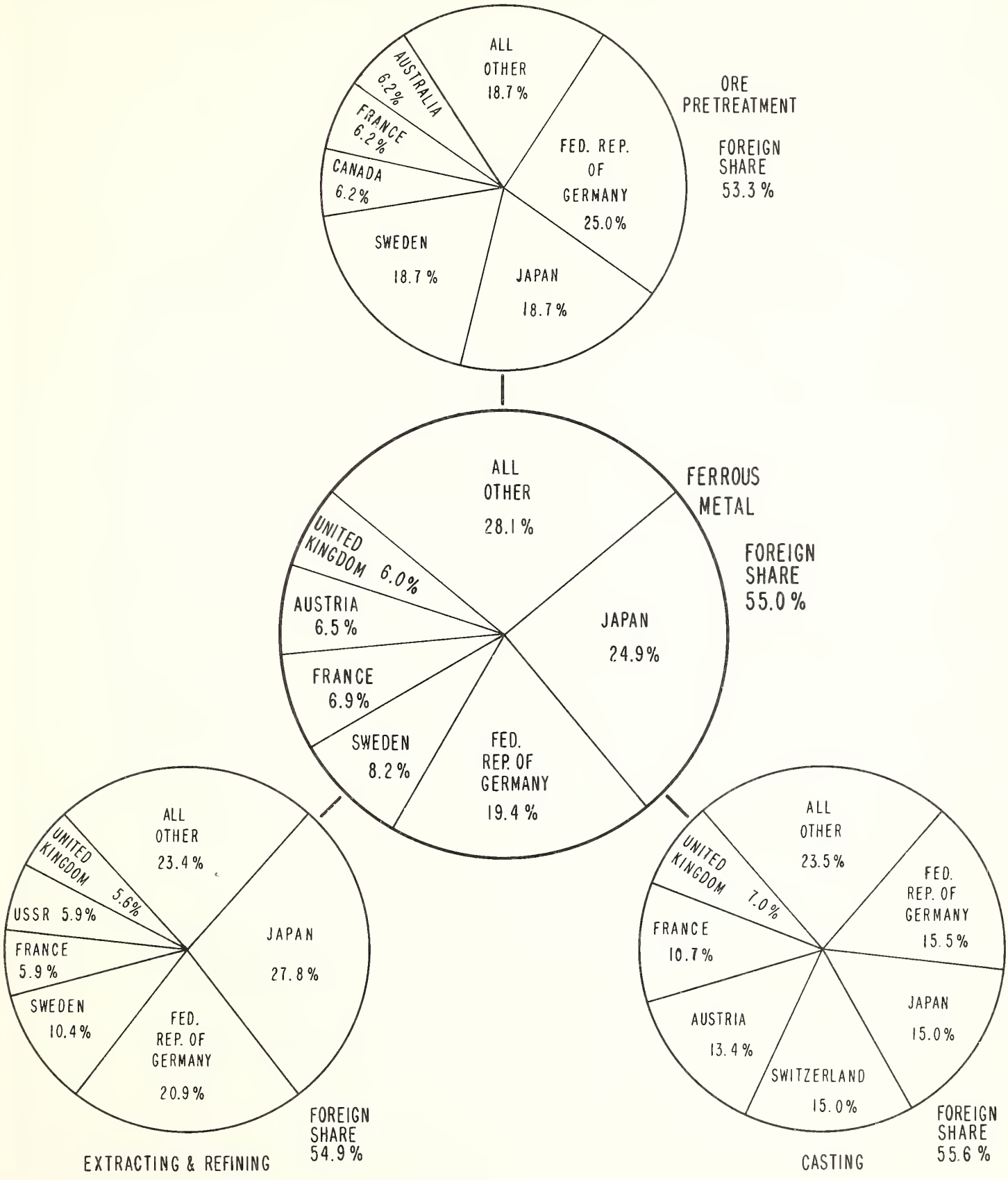


FIG. 3-8: FOREIGN SHARE OF U.S. PATENTING IN FERROUS METAL AND COMPONENT TECHNOLOGIES
3 YEAR AVERAGES 1968-1970 & 1973-1975

FIG.3-9: U.S. PATENTING BY RESIDENTS OF FOREIGN COUNTRIES 3 YEAR AVERAGE (1973-1975)



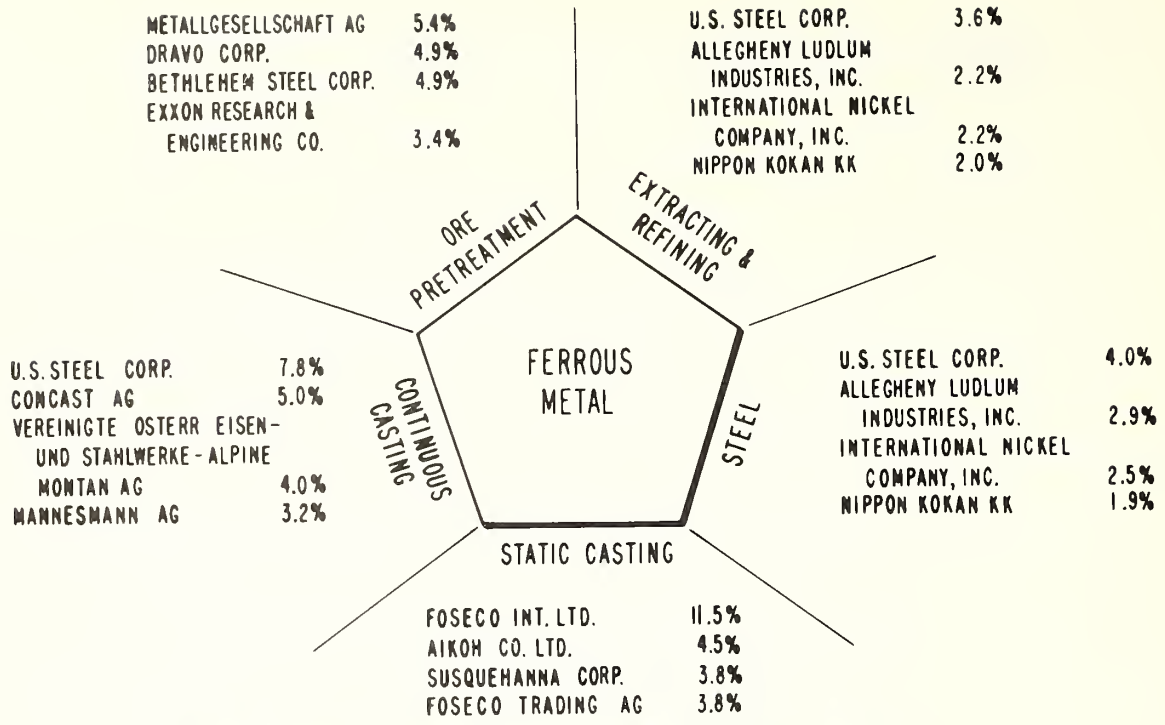
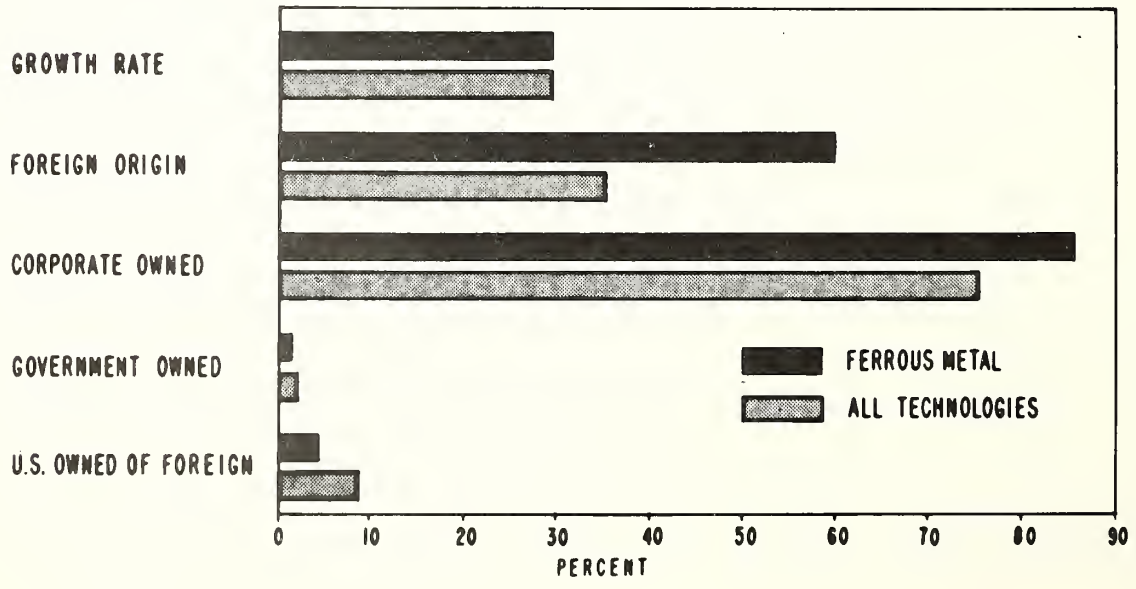


FIG. 3-10: PATENTING BY MAJOR CORPORATIONS IN FERROUS METAL TECHNOLOGIES JANUARY 1969-DECEMBER 1977

E. All Technology Comparison

How does Ferrous Metal technology compare with all technologies regarding growth rate, foreign activity, corporate and government ownership, and the extent to which foreign developed technology is owned by U.S. corporations? The answers to these questions are given in Figure 3-11.

FIG. 3-11: COMPARISON OF PATENTING PATTERNS FOR FERROUS METAL AND ALL TECHNOLOGIES 3 YEAR AVERAGE (1973-1975)



Growth rate is defined as patenting (by application filing date) for the period 1973-1975 over patenting for the period 1966-1975 expressed as a percentage. It is a measure of the amount of patenting in the decade 1968-1975 that occurred in the three year period, 1973-1975. Uniform patenting (10% a year) throughout this period would give a value of about 30% which is what is observed for both Ferrous Metal and all technologies.

"Foreign origin" is the extent of 1973-75 U.S. patented applications filed by foreign resident inventors divided by total 1973-75 patented applications filed expressed as a percentage. The figure clearly indicates that foreign activity in Ferrous Metal is significantly higher than the all technology average of 36%. The fact that foreign residents are now receiving more U.S. patents in this technology than U.S. inventors may indicate that foreign inventors have become more innovative than U.S. inventors in this industry or that a greater proportion of foreign inventions in the technology are now being patented in the U.S.(i.e., foreigners perhaps are becoming more internationally minded in the patenting of their inventions). The net result, in either case, is to place the U.S. ferrous metal industry at a disadvantage.

A comparison of the extent of corporate owned patents (1973-75 patented applications organizationally owned divided by total 1973-75 patented applications times 100) in Ferrous Metal and all technologies shows that more of the Ferrous Metal patents are corporately owned. This result is not surprising given the large capital investment required and the nature of this industry.

The extent of government activity in ferrous metal expressed as a percentage of all patented applications filed issuing in the last three year period 1973-1975 is small (1.7%) and less than that observed in all technologies (2.5%).

U.S. owned of foreign, in most cases, is a measure of the extent of patenting by foreign inventors which is supported and owned by U.S. corporations. For all technologies, the number of patents falling into this category amounts to about 9% of the total U.S. patents granted to foreign residents. For ferrous metal, the number is much less. Only about 4% of the patents issued to foreigners are owned by U.S. Corporations.

PART II

REVIEW OF SELECTED FERROUS METAL TECHNOLOGIES

The data presented in Part I are useful for answering the questions who, where and, to some degree what (how much) for various aspects of a major technology. To further answer the latter question as well as the question why, a review of substantive information contained in patents is required.

Patents, and particularly U.S. patents, are an unusually rich source of technological information for several reasons. First, as previously indicated, much of the information disclosed in patents is not disclosed elsewhere. Thus patents become a unique source of much of the substantive information of interest. Besides being unique, patented information is often disclosed in more detail and sooner than any other form of literature*.

U.S. patents also are a particularly good source of substantive technological information because they constitute not only a record of U.S. innovations but foreign ones as well. The majority of significant foreign inventions are patented in the U. S. because of this country's importance as a manufacture and consumer of manufactured goods.

The substantive information disclosed in patents is varied and can be used in many ways. Because a patent grant usually begins with an identification of the technology and a discussion of problems being addressed, patents are an excellent source of background information. The disclosure and claims of a patent address solutions to these problems, making patents an excellent source of state of the art information. Also, because patents within a given technology are categorized by grant date, they normally provide an excellent history of developments in the technology. A review of the earliest to the most recent patent issued in a technology is revealing, often amounting to the equivalent of reading a textbook in the area.

What follows is such a review of many components of Ferrous Metal. The information presented is intended, on the one hand, to be informative as to the "goings on" in the technology and, on the other, to be exemplary of the kind of substantive information - what and why - that can be readily obtained from patents.

This review begins with continuous casting of steel - an area of much recent interest and one that holds much promise for producing better and cheaper steel products. From there patent activity is explored in 17 other ferrous metal technologies from the beneficiating of iron ores to continuous methods of making steel. Included are key areas of major interest such as Q-BOP refiners.

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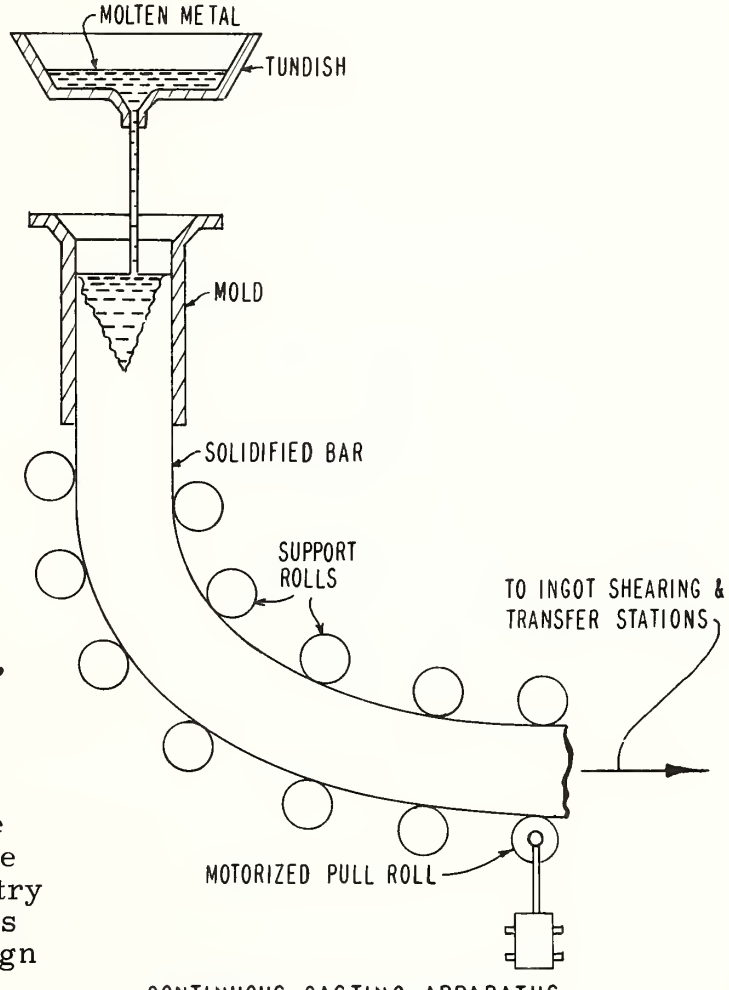
*F. Liebesny, Mainly On Patents, p. 120, Archon Books, 1972.

CONTINUOUS CASTING OF STEEL*

Continuous casting of metal is a technological concept which originated in the mid-ninteenth century(1). The basic concept is to use an open ended mold for casting an indefinite length product to the approximate dimensions of the final or intermediate product desired. Direct casting of elongated products such as lead pipe and steel sheet gave impetus to development of the process. Differing product requirements have given rise to two basic approaches to the continuous casting problem i.e., the fixed wall mold and the continuously advancing wall mold. The fixed wall mold has been oriented vertically, horizontally, and curved from the vertical toward the horizontal with a bend toward the horizontal to reduce plant height and thus cost.

Continuous casting technology, from a patent perspective, is an active technology. Over the past decade an average of approximately 120 patents have issued in this area. Two graphs on the following page illutstrate this growth, first by patent grant date and then by the application date of these patents. Also shown in these graphs is the U.S. vs foreign activity in the technology. In this area, as in other areas, a trend from predominantly U.S. to predominantly foreign origin patenting is evident over the period 1968-1977. In the most recent three year period, 1975-77, almost 61% of all patents were issued to foreign resident inventors.

The country table following the graph shows by patent grant date patent application date the country distribution of the patents in this field that were granted to foreign resident inventors.



CONTINUOUS CASTING APPARATUS

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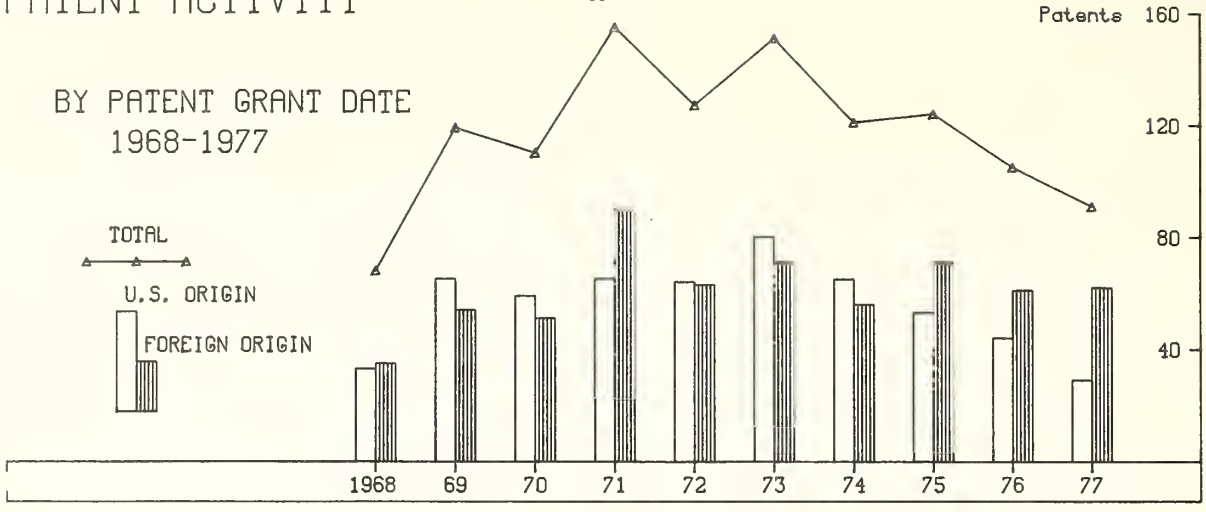
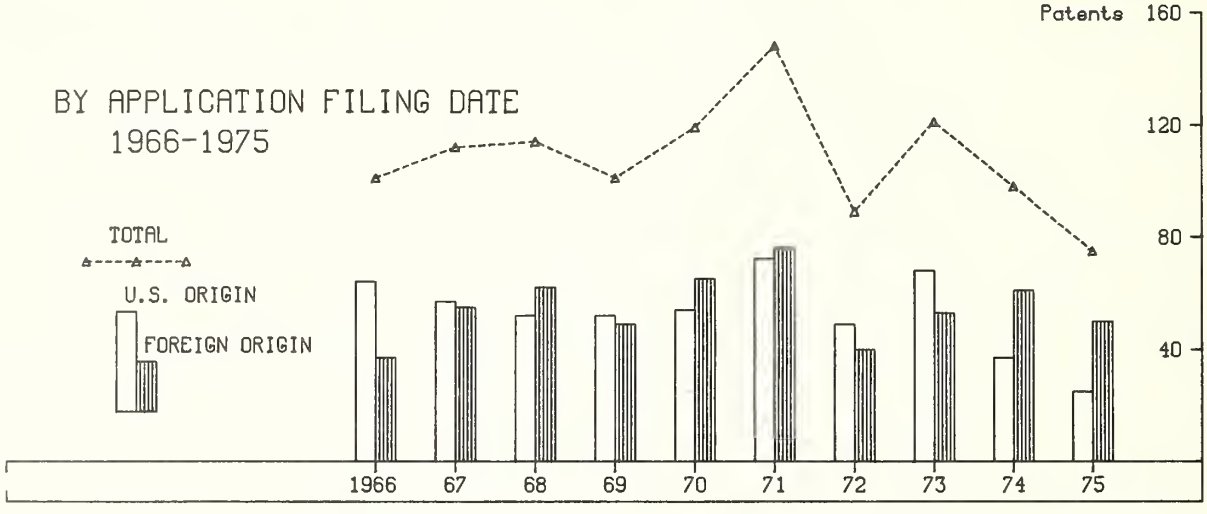
* The technology described in this report is contained in Class 164, Subclasses 73, 82-89 and 413-450.

PATENT ACTIVITY





DISTRIBUTION OF PATENTS IN AREA OF INTEREST

	BY PATENT GRANT DATE											BY PATENT APPLICATION FILING DATE										
	1968	69	70	71	72	73	74	75	76	77	TOTAL 68-77	1966	67	68	69	70	71	72	73	74	75	TOTAL 66-75
TOTAL PATENTS	68	119	110	155	127	151	121	124	105	91	1171	101	112	114	101	119	148	89	121	98	75	1078
UNITED STATES	33	65	59	65	64	80	65	53	44	29	557	64	57	52	52	54	72	49	68	37	25	530
TOTAL FOREIGN	35	54	51	90	63	71	56	71	61	62	614	37	55	62	49	65	76	40	53	61	50	548
GERMANY	6	13	14	29	21	16	10	12	6	13	140	9	13	16	16	20	22	6	7	9	10	128
SWITZERLAND	5	10	13	13	5	17	8	7	14	7	99	5	12	8	10	10	10	9	9	8	10	91
FRANCE	7	11	2	4	6	8	5	8	10	9	70	5	6	5	4	4	8	3	6	7	5	53
AUSTRIA	1	2	3	13	1	6	5	15	8	11	65	2	1	6	7	4	5	4	6	10	9	54
U.S.S.R.	5	5	6	10	7	4	9	6	4	1	57	3	12	6	3	7	6	7	5	4	2	55
UNITED KINGDOM	5	6	4	8	4	4	4	1	2	2	40	6	5	7	3	5	4	1	4		1	36
JAPAN	1	2		6	5	8	5	6	8	11	52	1	2	4	2	4	8	4	3	12	7	47
ITALY	1	2	3	4	7	4	3	3	3	3	33	3		4	3	8	3	2	4	3	1	31
CANADA	1	1	3	3	3	2	5	8	1	4	31	1	2	5		1	5	3	5	4	4	30
ALL OTHERS	3	2	3		4	2	2	5	5	1	27	2	2	1	1	2	5	1	4	4	1	23

Early molds had walls that diverged toward the outlet to prevent sticking (2) and later ones had walls that converged (3) to give prolonged strand contact for cooling purposes. Molds have usually been made of copper because of its good heat transfer properties, strength, and chemical inertness(4). However, graphite has been used as a mold lining material because it is self lubricating as well as being relatively inert and having a relatively high thermal conductivity(2). Coating a copper mold casting surface with chrome to control wear has been proposed(5).

The problem of the strand sticking to the mold held back the progress of continuous casting of the higher melting temperature metals, e.g., ferrous, until Junghans developed effective mold reciprocation(6, 7). The mold has been oscillated in a variety of motions (e.g., sinusoidal, accelerated segment, strip in withdrawal direction) to separate the sticking strand from the mold wall without causing a breakout of the molten core or a skin defect such as a wrinkle. It has also been proposed to reciprocate the strand in a stationary mold to reduce sticking.

The continuously advancing wall mold concept was first proposed by Sir Henry Bessemer as a method to cast sheet steel(1). In the Bessemer proposal a pair of water cooled rolls were placed on parallel horizontal axes with solidification of the melt taking place in the nip between the rolls. The direction of casting was down. Since then, casting roll axes also have been oriented vertically(8). The casting direction has been oriented upward and horizontal in addition to down. A single roll has been used with a stationary mold having an arcuate surface matched to the roll surface to create a casting space between the two.

Horizontal, open top, channel molds have been proposed. The end opposite the outlet is dammed with a deep intermediate part forming the pouring reservoir. In some devices the mold is a stationary member having cooling passages (9) while in others it is a moving web of a sacrificial material such as a mat of ceramic fibers (10). The mold may also be made of segments which move on a closed path through the casting area (11).

A variation of the continuously advancing wall mold is found in some composite casting devices. Steel sheet(s) is moved into formers which shape it to have a cavity the size and shape of the desired stand. With the seams pinched or welded shut molten steel is poured into the thus formed tube and solidifies (12, 13).

In recent years melt spinning of steel wire or filament has developed. In this technology steel is forced through an orifice to form a fine molten metal stream which is brought into contact with a gas which first forms a stabilizing oxide coating on the stream and then cools it to solidification (14). The process produces a homogeneous wire which is useful as a reinforcing material, as in tires.

Production of molten steel is a batch process so continuous casting of steel requires coordination of batching and casting. Molten metal is usually conveyed and stored in ladles which are filled at the furnace. Because molten metal tends to cool, segregate into its components, and change composition due to chemical reactions as it stands, the molten metal production has to be correlated with the throughput of the mold(s) to avoid development of problem metal. The ladle is emptied either directly into the mold or into a tundish which empties into the mold. In either case a nozzle and stopper erosion problem may develop due to the throttling required to maintain the melt surface at the desired height in the mold (15).

Pour tubes are often used to bridge the feed vessel and the mold. The tube prevents inclusion of atmospheric contaminants into the metal stream. It also allows control of the flow of the new metal in the mold to aid in the removal of both gaseous and particulate contaminants and to prevent scouring of the newly formed skin. Where there is no pour tube, a slag bed is often floated on the metal in the mold to remove impurities from the metal stream passing through it (16, 17 and 18). The slag may also wash the metal flow into the mold and suppress noxious gases generated in the mold.

Vacuum degassing may occur in a vertical leg metal feed chamber located upstream of the mold (19) or as the metal flows horizontally through a series of vessels to the mold (20). In the vertical leg feed chamber molten metal streams down into the mold feed reservoir as the entrained gases expand breaking the stream into droplets. The evolved gases are then evacuated from the chamber while the molten metal feeds into the mold and through the mold wall.

Lubricant may be added around the periphery of the mold inlet to aid the movement of the steel through the mold. The lubricant is usually an oil which is forced into the mold area through orifices(21) or through a permeable metal member(22). Contact with the hot metal causes dissociation of the oil into carbon and hydrogen. The carbon forms a slip--plane layer between the mold and the molten metal, thereby lubricating the passage of the strand. Glass has also been used as a mold lubricant in vertical downward casting(23). Molten glass is on the metal in the mold to be drawn down between the mold and metal forming a slip-plane layer. The glass may contain metal treating materials to help remove contaminants from the stream.

Gases evolved from the melt and generated by lubricant need to be vented to prevent entrainment in the product. In molds having open tops venting is not a problem, however, in closed top horizontal molds venting means may have to be provided. Some horizontal molds have venting grooves cut into the casting surface (24) while others have vent orifices or permeable metal inserts in the mold surface (21).

Mold cooling is accomplished by flowing coolant through a jacket surrounding the casting surface or by spraying coolant onto the outer mold surface. Some molds have special flow or spray patterns to obtain heat removal patterns which achieve special results such as reduced heat removal in the corners or increased heat removal at the inlet end (25).

Secondary cooling usually begins at the mold outlet with water being sprayed on the hot strand. The high temperatures involved in such spraying generate a steam layer called the Leidenfrost phenomena which reduces the cooling effect of the spray. Several patents have been devoted to overcoming this effect by use of combinations of stream velocity and direction to get under the steam layer (26, 27, 28). Spray nozzles are intermingled with the downstream strand support to obtain cooling of unsupported areas of the strand. Some strand support plates have been provided with orifices to feed coolant onto the strand face in the support area while others have merely had holes drilled in them to provide spray ports (29, 30). Some patents disclose a mold connected to a tank of molten salt or lead, through which the new stand is moved for support and cooling (31).

Roll stands are by far the most common strand support devices. Rolls may be adjustably mounted on support sections to accomodate variations in the size of the cast strand. Initially, operative plants used straight roller sections below straight, vertical molds with a cut-off device in a pit below the mold to produce lengths of casting which were hoisted out of the pit for working or storage. Later plants used a straight vertical mold with roller support sections that curved to the horizontal (32, 33). The curved support section effectively lowered plant height requirements thus eliminating the need for a pit or alternatively a high casting tower. With development of the curved mold, plant height requirements were lowered further as only part of the horizontal component was from the strand support. The ultimate in lowering of plant height requirements is embodied in the horizontal caster plant which has no vertical mold or support sections. Some strand supporters are just water cooled bars which are pressed into sliding engagements with the strand(29).

A variety of strand withdrawal devices have been used but as with the strand support devices the most common is the roll stand. The rolls are normally pressed into contact with the strand by hydraulic or spring biasing devices (34). Electric or hydraulic motors drive the rolls. Longitudinally movable clamps have also been used to grip the strand and pull it out of the mold (35, 36). Opposed, cooled walking beams have been used for strand cooling, support, and withdrawl.

A necessary element in any continuous caster is a means to plug the outlet end at the start of the process. Such devices are called starter bars. The starter bar is usually the shape of and slightly smaller than the mold cavity with an end configuration which grips the new casting. The starter bar usually is sealed in the mold by a flexible material such as asbestos (37, 38).

Whether saws, shears, or torches, all of the cut-off devices are flying cutters (34, 37). The cutter usually clamps to the strand to match speed before cutting. Strands may be hot worked and then severed or severed and worked. Working of the uncut strand is often done to eliminate casting defects, however, strand reduction may be the object. Where drastic

size reduction is made, roll and strand speed becomes a problem as approximately the same volume passes through the rolls per unit time, e.g., a four inch square billet reduced to a one inch square rod would pass through the last rolls about sixteen times as fast as through the first rolls.

Automated control has entered continuous casting technology with control unit systems that operate in both an open and closed loop mode. In open loop operation the control unit controls actuators on a time basis according to a preset program while in closed loop operation sensed inputs, e.g., temperature, water flow, speed, are monitored and reported to the control unit which responds by operating the actuators, e.g., for the tundish stopper rod, mold coolant, secondary coolant, and withdrawal rolls, in a preprogrammed manner. Some of the control units have the the capacity to vary programmed set-points in response to changes in sensed conditions. Control units have covered the spectrum from simple electrical comparators or threshold devices to programmable digital computers (39, 40, 41).

Technology Trends

Current developments are directed mainly at reducing the amount of superstructure required to support the curved guide rollers in vertical plants. The production of thin steel members, e.g., ribbon and wire, having an amorphous structure rather than a grain structure, by shock cooling, e.g., one hundred thousand degrees per second, has also seen much development lately (42).

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BENEFICIATING

Beneficiating involves concentrating the metal values of ores and rendering the ores more amenable to metallurgical treatment. *

Thomas Edison was one of the early innovators in this field. With the commercial success of his incandescent lamp assured, Edison turned his attention to transforming the relatively abundant, but low grade iron ores of western New Jersey into economically exploitable deposits. Though Edison made noteworthy contributions to the art, namely, pioneering the use of magnetism to separate iron rich from iron poor ore fractions, his considerable efforts in this field did not end in financial success (1). The reason for the failure of the venture was that his upgrading or beneficiating techniques, however clever, were not efficient enough to make low grade ore competitive with the high grade deposits of the Mesabi range, which were then just becoming abundant (2).

As the high purity ores (< 50% wt. Fe) of the Mesabi, and other deposits found primarily in the northern United States around the Great Lakes region and Canada, became depleted, interest revived in upgrading or beneficiating processes (3). Vast deposits of lower grade iron ores, such as taconites (30-35% wt. Fe) are still abundant.

Iron ores can be physically separated into two fractions: an iron bearing fraction and a non-iron bearing fraction. The latter is frequently referred to as gangue. In most iron ore, the iron is chemically combined with oxygen. In naturally occurring ores, the iron oxides exist as either magnetite (Fe_3O_4) or hematite (Fe_2O_3). Low grade iron ores have a high proportion of gangue. Consequently, the first step in processing low grade ore is to upgrade the ore, that is, to concentrate the iron oxide fraction by eliminating as much gangue as possible. Such beneficiating operations are invariably conducted at or near the mine site, thereby saving the cost of transporting gangue.

As iron oxides are denser that gangue, one of several gravity separation techniques can be employed to concentrate the iron bearing fraction. Only magnetite is magnetic enough to be amenable to concentration by magnetic separation, hematite being non-magnetic.

A favored beneficiating procedure is first comminuting, by crushing and grinding low grade ore and then subjecting the resulting particles to froth flotation. In froth flotation the separation of iron oxide from gangue particles is enhanced by adding frothers (soap-like bubble producing substances) to an aqueous suspension of comminuted iron ore into which air is blown. This generates a froth or floating layer of air bubbles. The gangue fraction of the ore exhibits a preferential affinity for the air bubbles (4).

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* Methods of beneficiating are classified in Class 75, subclass 1. Apparatus employed in beneficiating is classified in Class 266, subclasses 178-180.

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AGGLOMERATING

Agglomerating involves taking fine particles of ore and forming them into larger, compact aggregates.*

Having been comminuted to a finely divided condition prior to beneficiation, the enriched ore fraction resulting from a beneficiating operation exists as fine particles. In this state the ore is not suitable for smelting, as particles of such small size would be blown away in the draft of the blast furnace (1). As this is also true of: (i) the tailings and sludges emerging as by-products from the processing of high grade ores; and (ii) the flue dusts effluent from the blast furnace, B.O.F. and Q-BOP converters, recycling of these "wastes" also involves an agglomerating operation (2, 3).

It should be noted that agglomerates actually have an advantage over lump ores. Because of their relatively small and uniform size the capacity of the blast furnace is materially increased (4, 5). Agglomerates or aggregates are formed into one of two general shapes: Pellets, which are essentially spherical; and briquettes, which are essentially block shaped (6).

A typical agglomerating operation involves first blending damp iron ore particles with a binding agent and possibly also a powdered reducing agent and/or a flux (then moistening the mixture if dry ore was used) and compacting, molding or rolling the mixture into agglomerates in a ball mill, disk or drum pelletizer, some other type of agglomerating device, and finally subjecting the green (or unheated) agglomerates to elevated temperature to dry and harden them (7). The heating operation, which is sometimes referred to as indurating, also effects a partial reduction of the ore (8). Hardening is accomplished by a sintering or partial fusion of the particles (2). Hardening may be enhanced by subjecting green pellets to steam under pressure (9). The binder, such as bentonite or other clay-like material, is employed merely to avoid a fracturing of the fragile, friable green agglomerates (4). Where the agglomerated particles are transferred to a blast furnace immediately after being agglomerated, the drying and hardening operation also "preheats" the agglomerates (10). Typically, the pre-heating operation is conducted either on a travelling (or endless) grate (11) or in a rotary kiln (12). In either type of apparatus there are distinct zones maintained at different temperature levels, the agglomerates proceeding from cooler to hotter zones (13). The temperature in the hottest zone or stage is high enough to effect sintering (2300-2500 ^{o}F) (14).

There has been relatively little patent activity in the agglomerating art. Recent patents dealing with agglomerating are not concentrated in any one or two categories, but rather propose refinements or improvements upon several aspects of the basic process described above. For example, one patent discloses a procedure for the automatic control of the agglomerating process (15), while another proposes the addition of an alkali metal or ammonium silicate to the sinter mix prior to its fusion in order to reduce the amount of dust generated (14).

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* Methods of agglomerating are classified in Class 75, subclasses 3-5. Apparatus employed to effect agglomeration is classified in Class 266, subclass 168.

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REDUCTION

Reduction involves the chemical transformation of iron ore to metallic or elemental iron. *

Most steel is the product of an essentially two stage process. The first stage involves a relatively crude chemical reduction of iron oxides to pig iron (a form of metallic iron relatively rich in carbon, silicon, manganese, and phosphorus). The second, or refining stage, involves a carefully controlled elimination by oxidation of excess carbon, silicon, manganese, and phosphorus.

Blast Furnace Smelting

The conventional means of effecting the reduction of iron oxides is the blast furnace. Reduction of iron oxide to metallic iron in the blast furnace is accompanied by the melting of the iron. Metallurgical reactions which involve simultaneous reduction and melting of the reduced metal are referred to as smelting operations.

A blast furnace is a tall tower having a shape that is essentially that of a long slightly tapered cone mounted on top of a short inverted cone. These walls enclose a central chamber, which is open at the top and has three fairly well-defined regions, an upper or stack section, where preheating occurs; a middle or bosh section, where melting starts; and a lower or hearth section, where molten metal and slag collect. Preheated air is injected into the hearth section through tubes called tuyeres. Modern blast furnaces are composed of a thick steel shell and a much thicker lining of refractory bricks.

A blast furnace is operated by charging iron oxides, fuel (coke) and flux (limestone or dolomite) either as agglomerates or as separate entities. Coke is nearly pure carbon produced by the destructive distillation of coal. Limestone ($CaCO_3$) and dolomite ($CaCO_3 . MgCO_3$) are minerals that facilitate the separation of iron from the non-ferrous component (gangue) associated with ferrous oxides.

By adding a flux the molten iron and gangue will separate as two distinct phases, as do oil and water. Being less dense the non-metallic or slag phase, which is composed of molten flux and gangue will float on the metallic or iron phase.

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*Processes involving blast furnace reduction are classified in Class 75, subclasses 41 and 42. Reduction of iron ore in electric furnaces is classified in Class 75, subclass 11. Blast furnaces per se are classified in Class 266, subclasses 197-199. Electric are furnaces per se are classified in Class 13, subclass 9. Fluidized bed reduction processes are classified in Class 75, subclass 26. Fluidized bed reactors are classified in Class 266, subclass 172. Other direct reduction processes are classified in Class 75, subclasses 32-37. Direct reduction apparatus in classified in Class 266, subclasses 158 and 168.

The function of the coke in the charge is two-fold: first, to supply enough heat to attain the necessary temperature for the metallurgical reactions to take place, and second, to supply the reducing agent for the process. In some modern blast furnaces, a portion of the heat needed to attain the necessary temperature for the metallurgical reactions is generated by injecting fuel oil into the bosh section of the central chamber (1).

Where the reactants are charged as discrete entities, rather than being agglomerated together, it is common practice not to attempt to mix the reactants, but instead to stack a series of relatively thin alternating layers of each reactant (2). The components of the charge are added through an opening at the top of the furnace.

When the smelting of a charge is complete the furnace is tapped by making a hole in the hearth section of the furnace, typically with the aid of a drill. After the furnace has been tapped, the hole is patched by injecting refractory mud into the opening (3).

Contemporary blast furnaces are essentially the same as the blast furnaces of a hundred years ago. The two aspects of blast furnace technology in which there have been some patent activity are: (i) the automatic control of the process (4-6); and (ii) the use of supplemental or auxiliary combustible fluids to at least partially replace metallurgical coke (7-9).

Electric Furnace Smelting

As already noted, in the blast furnace, carbon in the form of coke serves a dual purpose: supplying the heat needed to melt the charge and acting as a reducing agent for the iron oxides. If a source of heat other than carbon can be used to melt the charge, carbon is used only as a reducing agent. Thus, where electric power is relatively cheap and coke scarce, smelting can be carried out in an electric furnace. In electric arc smelting either just enough coke needed to reduce the iron oxides or only a slightly excess amount needed for reduction is incorporated in the charge (10).

Direct Reduction Processes

So called direct reduction processes effect reduction of iron oxides without a melting or fusion of the iron reduced (11). The term "alternative reduction" has also been applied to such processes (12).

The term "roasting" is applied generally to metallugical processes involving heating without melting. Although most roasting operations are oxidizing roasts (employed to convert sulfides to oxides), reducing, chloridizing, and sulfatizing operations which are carried out without melting have also been characterized as "roasting" operations (13). Usually the term roasting is reserved for preiminary or intermediate operations which do not result in the production of free (elemental) metal.

Direct reduction processes are usually carried out in a shaft furnace or rotary kiln. A mass or bed of finely divided ore is contacted with a reducing gas at elevated temperature (1000-1800° F) (14). This effects

a reduction to metallic iron. The iron oxide particles and reducing gas must be brought into intimate contact in order for reduction to occur.

It has been found that such contact can be promoted by maintaining the mass of particles in a fluid or turbulent condition (5). Direct-reduction processes wherein the mass of ore being reduced is maintained in a fluidized state are referred to as fluidized bed processes as opposed to direct reduction processes wherein conditions of turbulence do not prevail. The latter are referred to as static bed processes. Static bed processes generally proceed more slowly and have other shortcomings, namely, localized overheating, incomplete reaction in localized areas, and ineffective removal of reaction antagonists (15). Fine particles are not amenable to treatment in static beds, as the fine particles interfere with bed permeability (16).

Several serious problems also exist in attempting to reduce iron oxides in fluidized beds. One of the most troublesome is a phenomenon known as "bogging", or defluidization. It is manifested by a stickiness at the surfaces of the individual solid iron ore particles. Apparently, the surfaces of the individual ore particles become covered in whole or in part, depending on the temperature, with the crystalline form of iron. These crystalline forms, microscopic in character, often take on the appearance of nodule whiskers extending outwardly from the individual reduced ore particules. Because of these projections, the particles tend to attach one to another upon contact so that individual iron ore particles cling or melt together to form aggregates or agglomerates. Such phenomenon militates against proper fluidization of the particles and hence, bogging or loss of fluidization of the bed occurs (17). A related problem is sintering. The latter is caused by an actual melting of the reduced iron upon the surfaces of the particles (18).

Another problem is "catastrophic carbonization" which is defined as the reaction that occurs when carbon is deposited from a gas containing carbon monoxide onto a metal surface. Some of the carbon deposited reacts with the metal surface to form a metal carbide which, in turn, catalyzes the reaction causing the deposition of more carbon at a more rapid rate. The deposition of carbon will cause plugging and failure of equipment due to pressure buildup whereas the carbonization of the metal surface will cause pitting, weakening and failure of the metal surfaces and equipment (19).

Yet another problem encountered with fluidized beds is a phenomenon known as "decrepitation", which is manifested by the production of an excessive amount of "fines", i.e., small particles generally ranging from about 0.5 micron to about 44 microns (20).

Many of the patents relating to fluidized beds suggest ways in which the adverse effects of bogging, sintering, catastrophic carbonization, or decrepitation can be obviated or at least minimized. For example, several patents endeavor to inhibit bogging by employing certain basic nitrogenous compounds such as ammonia (21). Others suggest as a solution the use of oxides and carbonates of certain metals as additives (17, 22).

Typically, the fluidized bed reduction of iron ore is carried out as a staged operation in order to efficiently utilize reducing gases. Iron ore is passed downwardly through a series of fluidized beds countercurrent to the flow of the reducing gases (23). The gases fluidize and heat the iron ore in the beds as well as reduce it. In the primary stage, the higher oxides Fe_3O_4 and/or Fe_2O_3 are reduced substantially to FeO, while in a secondary stage the FeO is reduced to metallic iron (24). In conventional processes the reducing gases employed will generally be carbon monoxide and/or hydrogen. The use of excessive concentrations of carbon monoxide is avoided, as this will promote catastrophic carbonization. Several patents address themselves to the substitution of hydrocarbon for hydrogen and carbon monoxide. In addition to promoting bogging and sintering, hydrocarbons have been found to possess poor thermal characteristics as a reducing agent for oxidic ore (25).

Direct reduction processes can be used to reduce oxidic iron ores to metallic iron or they can be used in effect, as a beneficiating process to reduce the higher oxides of iron to FeO. In such case, final reduction to metallic iron is usually accomplished in an electric furnace. It should be noted that the product of such partial reduction is only FeO in the statistical sense. That is to say, some particles will exist as metallic iron whereas others will not have been reduced at all. Iron having an average or statistical oxide content equivalent to FeO is sometimes referred to as "Wustite" (26).

The metallic iron resulting from direct reduction processes, being porous, is referred to as sponge iron (27). Because of its porosity it is a relatively poor conductor of heat and electricity and consequently relative difficulty is experienced in melting it (28).

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THE BESSEMER PROCESS

The Bessemer Process was the first large scale process for effecting the conversion of pig iron into steel. Bessemer found that iron could be converted to steel more efficiently if air was blown or injected into molten pig iron. *

Although it is reckoned that the Iron Age began somewhat before 1000 B. C. (1), it is generally agreed that the Age of Steel had its inception only little over a century ago with the introduction of the Bessemer Process (2).

Steel is an alloy of iron and carbon which contains up to about 2% by weight of carbon (3). This range of carbon concentrations endows the alloy with a degree of malleability and strength that makes it uniquely suited for a plethora of industrial and consumer products.

Most of what little steel was produced before the introduction of the Bessemer Process was made by the costly Crucible Process. It involved first making carbon-free or wrought iron in a shallow furnace from molten pig iron by removing nearly all the carbon with solid iron oxides and then adding, in a clay crucible, (whence the name "crucible process") just enough carbon to the molten iron to produce steel (4).

The Bessemer Process (also known as the converter or pneumatic process), which was invented in Great Britain by Sir Henry Bessemer and, independently, in the United States by William Kelly, reduced the cost of making steel to the point where its mass production became feasible. The Bessemer Process is regarded as one of the greatest inventions of all time (5). Although Bessemer was granted a United States patent in 1856 (6), Kelly was subsequently able to establish in the United States that he had conceived the process as early as 1847 and had been diligent in reducing his invention to practice. In recognition of this, a United States patent was granted to him in 1857 (7), which patent was reissued later that year (8).

The Bessemer Process was based on the discovery and realization that the carbon present in situ in pig iron is of itself sufficient to create enough heat when combined with oxygen to maintain pig iron in a fluid state -- a fact that was recognized in both the Bessemer and Kelly patent specifications. Accordingly, no external heat is supplied during the process. Subsequent research established that in fact several strongly exothermic or heat-generating reactions occur in the Bessemer Process. Oxygen introduced into molten pig iron oxidizes not only carbon contained therein but also silicon, manganese, and phosphorus, one after the other, in the following order: Si, Mn, C, P (9). The transformation of pig iron into steel by the Bessemer process is relatively rapid, taking between 15-30 minutes.

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*The Bessemer Process is classified in Class 75, subclass 60. Bessemer converters are classified in Class 266, subclass 243.

Typically, the Bessemer Process is carried out in a barrel or pear-shaped vessel, known as a "Bessemer Converter". The vessel is called a "converter" because therein pig iron is transformed or converted into steel. The converter is open at the top. Through this "mouth" the charge is introduced and the molten steel removed. Oxygen-containing gas at ambient or room temperature, as jets under pressure, is introduced or "blown" from beneath the surface of the melt of pig iron through numerous small tubes or pipes, known as tuyeres. The converter itself is tiltable, being rotatable about a fixed horizontal axis. The charge is introduced when the converter is on its side or horizontal position. The converter is then turned upright to a vertical position and the "blow" occurs. The converter is then tilted downward and the steel allowed to pour out. The charge normally consists of molten iron, at temperatures of between 2000 and 2400° F. Solid steel scrap may also be added to control the temperature of the melt.

The converter consists of an outer shell composed of cast iron and a lining of refractory bricks. The original Bessemer converter was lined with bricks having an acidic or siliceous character, namely, sandstone or mica. In the so-called "Basic Bessemer" or "Thomas Converter" the lining possesses a basic character being composed of burned magnesite or dolomite. A basic lining was found necessary for refining pig irons possessing a high phosphorous content. In the Thomas Process, high-phosphorous pig iron (P>0.5%wt) is refined in a converter lined with brick of burned magnesite with the aid of a basic flux (usually lime) (10). No flux is normally added to the charge when it consists of low-phosphorous pig iron, the slag consisting of the oxides formed by the oxidation of the metalloids in the pig iron. The capacity of some Bessemer Converters was as high as 30 tons.

While the Bessemer Process and such modifications as the Thomas Process made available large quantities of inexpensive steel, certain shortcomings inherent in the process soon became apparent:

i. When air or even oxygen-enriched air was blown, unacceptable levels of nitrogen from the air become incorporated in the steel, resulting in its embrittlement (11).

ii. Because the conversion of iron to steel in the Bessemer process is so rapid, difficulties arose in determining just when the conversion was complete (11).

iii. To insure sufficient silicon and manganese in the pig iron to generate enough exothermic heat to sustain the process, it was frequently necessary to prepare a special Bessemer iron charge containing adequate quantities of these elements (12).

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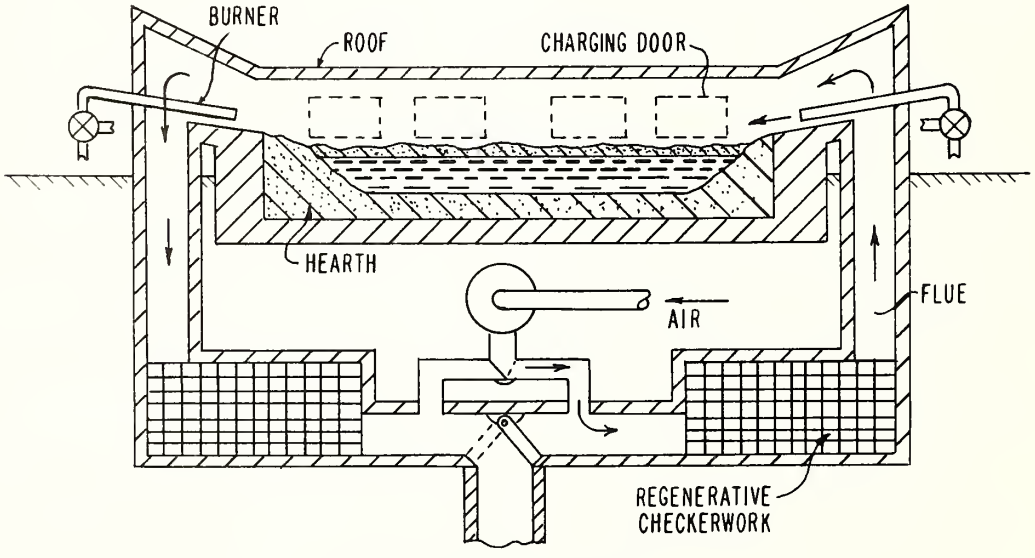
THE OPEN-HEARTH (Siemens-Martin) PROCESS

The Open Hearth Process is a process for converting iron into steel. Air is combined with solid oxides and introduced into a bath of molten iron that is contained in a special type of furnace, known as an Open Hearth. This process first appeared about a decade after the Bessemer Process. *

Although the cost of producing steel by the open-hearth process exceeded that by the Bessemer Process, in that it takes 10-12 hours to produce a batch of steel and requires external (gaseous or liquid) fuel, it yields steels low in nitrogen and steel having compositions that can be more accurately controlled. It is the much longer duration of the process that allows samples to be taken and the composition of the product adjusted during processing. The much greater time required to produce a heat of steel could be compensated for to an extent by employing furnaces having as much as a 600 ton-capacity, although in most cases the capacity is about 200-300 tons. Since the process does not depend upon the source of iron for the heat needed to sustain the reactions, there is greater flexibility in selecting the composition of the iron-bearing charge.

The prototype open-hearth furnace, illustrated below, was conceived by Karl Wilhelm Siemens, a naturalized British subject (1-4). It consists of a relatively shallow rectangular shaped basin or hearth, a low roof,



OPEN HEARTH APPARATUS

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* The Open-Hearth Process is classified in Class 75, subclass 60. Open-Hearth furnaces are classified in Class 266, subclass 214.

and a series of ducts in both of the shorter sides of the hearth, which communicate with an elaborate system of chambers or "checkers" beneath the hearth. In operation, fuel and a quantity of air more than sufficient to burn the fuel are both forced out through separate ducts on to the hearth at one end while the hot exhaust gases produced by combustion of the air and fuel are removed by the ducts disposed at the other end. These hot exhaust gases are then passed through the checkers where part of their heat is absorbed in the surrounding brick work. The flow of gases between the ends of hearth is periodically reversed (about every 14 minutes) so as to preheat incoming gas and fuel by passing them through the checkers and ducts previously heated by the exhaust gases. The series of such reverses produces a higher temperature in combustion than could be obtained without preheating (5).

In the open-hearth process, carbon contained in the pig iron is removed both by oxygen in the air of the furnace atmosphere and that contained in the iron oxides fed to the bath.

In the original Siemens process the source of iron consisted of pig iron and iron ore. The Martin brothers diluted the charge with steel scrap to such an extent that less oxidation was necessary (6, 7).

To make steel by the open-hearth process the furnace is first charged with scrap iron oxides, and a flux (limestone). These are then heated until fusion has started (2-4 hours). Only then is the molten pig iron added. A typical charge might consist of about 50% wt steel scrap and 50 wt pig iron. The boiling mixture is then cooked for 6 to 10 hours. Silicon, manganese, and phosphorous react with the limestone flux to form a slag (8).

As with the Bessemer converter, the open-hearth furnace may be lined with bricks having either an acidic or basic character, the choice being determined by the phosphorus content of the pig iron component of the charge.

The proportion of steel produced by the open-hearth process steadily increased. By 1908 the annual tonnage produced in the United States by the open-hearth process exceeded that produced by the Bessemer Process. In 1950 the proportion produced by the Bessemer Process represented less than 5% of the total annual U. S. output (9).

The chief disadvantage of the open-hearth process is the time necessary to produce a batch of steel. Accordingly, patent activity in open-hearth technology has concentrated upon the deployment of supplemental or auxiliary air-fuel burners (10), oxygen lances (11) and oxy-fuel jets (12, 13) in various positions about the hearth for the purpose of reducing the time needed to produce a batch of steel.

Many duplex and even multiplex processes have been developed. These couple two or more steel-making process (such as the Bessemer process and the open-hearth process) in sequence in order to take advantage

of the desirable attributes of each (14-16). Another example of duplexing involves the utilization of a bottom blown acid-lined Bessemer converter to remove silicon, manganese, and a part of the carbon from molten pig iron and then a side blown basic lined converter for reducing the phosphorus and the remaining carbon (17).

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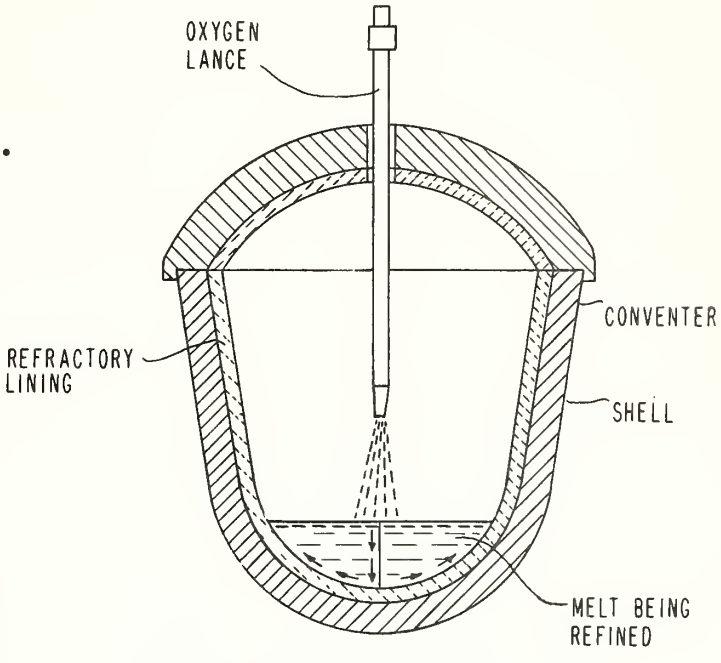
THE B. O. F. (LD-) PROCESS

The basic oxygen process is a method of converting iron into steel by injecting a jet of pure oxygen into a molten iron from a position above the melt surface. * A typical B. O. F. or LD converter is shown in the illustration.

Much of the objection to the Bessemer process resulted from the use of air which introduced into the steel levels of nitrogen unacceptable for some applications.

In Bessemer's day the only known method of obtaining pure oxygen in industrial quantities was by electrolysis, that is, by the costly process of electrically inducing the chemical decomposition of water. In 1898 Dr. Carl Linde in Germany demonstrated that oxygen could be physically extracted from air by liquification. However, it was not until 1928 that Fraenkl in Germany developed a process, for producing oxygen according to Linde's teachings that made a process using pure oxygen commercially feasible.



B.O.F. OR LD CONVENTOR

Bessemer in his basic patent, taught the use of air or oxygen-enriched air. With the availability of relatively inexpensive oxygen, attempts were made to carry out Bessemer's teachings. However, the violence of the reaction between the oxygen and the melt at the point of introduction was so great as to result in an erosion of the tuyeres and surrounding refractory lining at an unacceptably rapid rate (1).

In 1943, Dr. Carl Schwarz obtained a German patent on the process of blowing onto the surface of the molten metal bath at "such a high kinetic energy that it is capable of penetrating in the manner of a solid body deep into the bath". Schwarz gave very few instructions on how this top blown or blowing on to the bath from above was to be effected, but did indicate that oxygen enriched air or oxygen itself was to be used and that its introduction into the bath would bring about the high temperature required for oxidation away from the refractory walls and thus save them from rapid deterioration (2).

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*The basic oxygen process is classified in Class 75, subclasses 52 and 60. Basic oxygen furnaces are classified in Class 266 subclasses 225 and 226.

In 1946 John Miles of London was granted a patent in Belgium which taught the introduction of an oxidizing fluid at such speed that a sufficient proportion of the fluid penetrates the metal. According to Miles teachings the fluid was to contain no more than 30% nitrogen. The instructions given by Miles were fuller than those given by Schwarz and even expressed the resulting effect of the injected oxygen into the bath by saying: "The penetration of the jet also fulfills the useful function of agitating the bath so that the reactions take place uniformly and to the maximum extent" (3).

As one U.S. district judge noted, steelmakers did not come running to see and believe what John Miles had asserted in his patent. Ironically, it was the destruction in World War II of the Third Reich's steelmaking facilities which provided the impetus for the development and adoption of pure oxygen in a Bessemer-type process (4).

When the Austrian Government decided to re-establish the steel plants which had been destroyed by the Allies during the war, it faced the question of heavy investment in re-establishing the open-hearth furnaces or of finding something more modern. The Austrian government approached Dr. Robert Durrer and Dr. Heinrich Hellbruegge of the Von Roll Steel Works in Gerlafingen, Switzerland, who had in 1948 commenced a series of experiments on the teachings of Schwarz. This led to the establishment of a converter at Linz to experiment on the Schwarz process. On June 3, 1949 tests at Linz were made. The violence of the reaction caused the rupture of the water jacket surrounding the lance nozzle resulting in the spraying of water on the surface of the molten bath. Although this was an accident, it resulted in producing better steel than had been expected. This accidental occurrence and its result made them curious and they began to wonder whether or not the deep penetration of the prior art was really a necessity in the oxygen application to the iron bath surface. A series of tests confirmed that a normal type nozzle raised 15 centimeters above the bath surface produced a better quality of steel that was produced by a Laval (high velocity) nozzle raised only 10 centimeters above the bath. After 250 tests carried out between June 1949 and November 1950, they had a process for making industrial steel with as low concentrations of nitrogen, carbon, phosphorus, and sulfur as could be produced by the open hearth process (5).

The Austrian government established two plants, one at Linz and one at Donawitz embodying the practice developed at Linz by Drs. Theodore Suess, Herbert Trenkler, Hubert Hauttmann, and Rudolf Rinesch. The process was called the Linz-Donawitz or LD-process in honor of the two Austrian cities in which the process was first put into practice. In the United States, the process is generally known as the basic oxygen process. The word "basic" appears in the name because the converter is lined with basic refractory bricks. LD converters or furnaces are essentially cylindrical in shape, having capacities ranging from 60 to 200 tons. They are called basic oxygen furnaces (B.O.F.).

Like a Bessemer converter, a basic oxygen vessel is open at the top. It is through this opening that the oxygen-jet is lowered. The oxygen-jet equipment typically consists of a tubular water cooled, copper-tipped retractable lance kept in a vertical position above the center of the opening (6). An additional opening, to facilitate the separation of slag and metal during pouring, is disposed on a side of the vessel well above the upper surface of the slag.

Oxygen is blown at a pressure of between 140 and 180 lbs per sq. in. Carbon monoxide is evolved during the process giving rise to a vigorous action. Fluxes (chiefly burnt lime, fluorspor, and mill scale) are added after blowing begins. These materials serve to produce a slag of the desired basicity and fluidity (7).

A major advantage of the basic oxygen process is its flexibility in handling raw materials of many types and compositions. An appreciable quantity of scrap (12 to 30%) can be employed in the process. Scrap is also used for temperature control.

This major advance in steelmaking which was patented became the subject of extensive litigation. United States and foreign patent rights to the Suess et al patent were assigned to Vereingte Oesterreichische Eisen Und Stahlwerke Aktiengesellschaft (hereinafter VOEST), a steel company owned by the Austrian government. After protracted infringement litigation brought by Kaiser Steel Corporation, VOEST's exclusive U.S. licensee, the U.S. District Court for the Eastern district of Michigan, while cognizant that the invention constituted a technological breakthrough, "reluctantly", held the patent invalid (8). This holding was affirmed by the Sixth Circuit Court of Appeals (9).

Meanwhile, Kaiser Industries Corporation, in attempting to enforce the Suess et al patent, had brought suit against another alleged infringer, namely, Jones & Laughlin Steel Corporation in the Western District of Pennsylvania. In a voluminous opinion, Judge Rosenberg held the Suess et al patent valid and infringed, notwithstanding the earlier holding of invalidity. Judge Rosenberg was of the opinion that the McLouth District Court erroneously believed that the essence of the Suess patent was embodied in the concept of avoiding deep penetration. Judge Rosenberg believed that it was not the physical penetration of the oxygen jet that produced the desired result but a sequence of chemical reactions described in the Suess specification (10).

On appeal, the U.S. Court of Appeals for the Third Circuit reversed, not on the merits, but solely on a legal technicality (11).

Most of the patent activity in basic oxygen technology has been concerned with either the automatic control of the process or with the treating of the off-gas effluent from the basic oxygen converter. Separate sections of this report deal with each of these problems.

A few patents call for the manipulation of the position of the oxygen lance (12, 13) or the use of special flux compositions in order to more effectively remove phosphorus (14, 15). Where a slag rich in lime is maintained in order to effect the conversion of high phosphorus pig iron, the process is sometimes referred to as the LDAC process (16).

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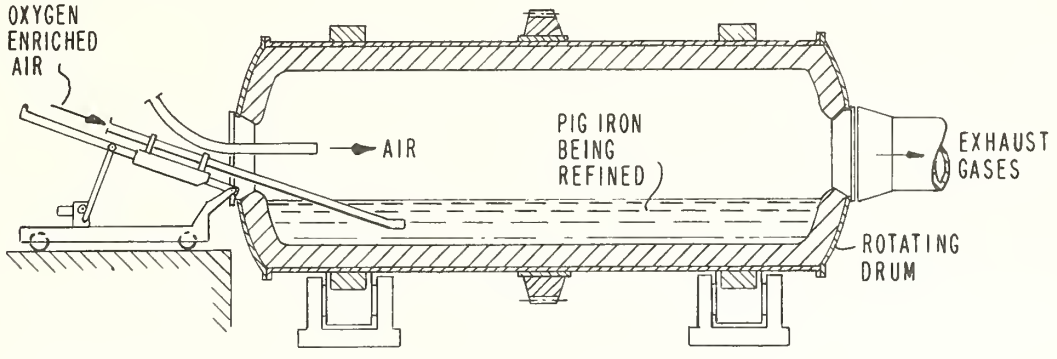
THE KALDO PROCESS AND THE ROTOR PROCESS

In both the Kaldo and Rotor processes iron is converted into steel by the blowing of oxygen into a rotating vessel.* In the apparatus shown below, air is blown above the melt and oxygen enriched air is injected below the melt, contained in a rotating drum.



APPARATUS FOR CARRYING OUT
THE ROTOR PROCESS

Bessemer's process, as Bessemer envisioned it, involves blowing air into a vessel from beneath the melt's surface. In his early disclosures this was to be accomplished by disposing tuyeres in the bottom of the vessel (1). However, in 1862 he patented a variation in which the tuyeres, though still disposed below the melt's surface, were to be located in the side walls of the vessel (1). In 1891 F. A. Tropenas proposed a converter in which the tuyeres were to be located in the sidewalls just above the melt's surface. Tropenas, moreover, taught tilting the converter during the blow so that the air jets would be directed obliquely downward onto the surface of the melt. The advantage of surface blowing is that additional heat is generated resulting in hotter steel (3200°F). This is particularly advantageous where small capacity converters are employed, as in foundry operations . The reason for the higher temperature in surface blown converters is that since much of the carbon evolves from the melt as carbon monoxide rather than carbon dioxide, the presence of oxygen at or above the surface of the melt causes the carbon monoxide to burn to carbon dioxide, thereby generating additional heat.

This principal has been incorporated in what has become known as the Kaldo process, after its principal inventor Professor Bo Kalling of Sweden (2). An LD-like converter is inclined at about a 17 angle from the horizontal and rotated at speeds of up to about 30 rpm while a jet of

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* The Kaldo and Rotor processes are classified in Class 75, subclass 60. Apparatus for carrying out these processes is classified in Class 266, subclass 244.

pure oxygen is blown through a lance from the mouth of the converter onto the surface of the melt which is covered with a basic flux. Combustion of the majority of carbon monoxide to carbon dioxide within the converter vessel substantially increases the thermal efficiency of the process, while the inclination increases the productive capacity of the vessel and exposes more of the lining to the cooling effect of the metal during rotation. Rotation increases slag-to-metal contact thus enhancing the elimination of phosphorus.

The so-called Rotor Process resembles in some respects the Kaldo Process. As in the Kaldo process, oxygen is introduced above the surface of the melt while the vessel is rotated. However, in the rotor process: (i) oxygen of different concentrations is simultaneously introduced both above and below the melt surface: a lance opening above the melt surface carries relatively low purity oxygen (as low as 45%), while a lance opening below the melt surface carries high purity oxygen; (ii) the speed of rotation is slow (1/2 to 2 rpm); (iii) the vessel is in the shape of a rotary kiln (i.e., cylindrical) rather than an LD-converter; (iv) the vessel is maintained in a horizontal position during operation, being tilted only during charging and discharging (3).

As in the Kaldo and surface blown Bessemer processes, the function of the oxygen introduced above the bath is to burn carbon monoxide to carbon dioxide.

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2. 2,598,393	Kalling et al	----	Sweden
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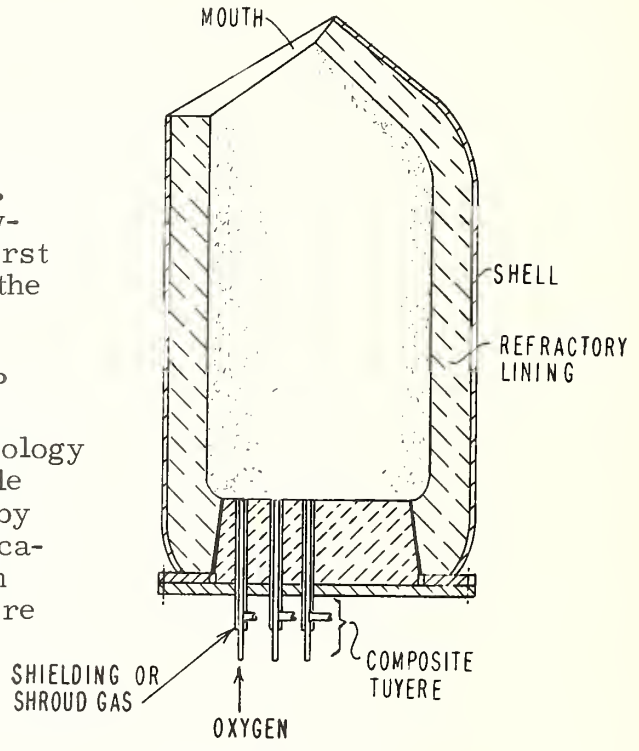
THE Q-BOP (O. B. M.) PROCESS

The Q-BOP or O. B. M. (oxygen bottom blowing Maxhutte) process pertains to the conversion of pig iron into steel by the injection of oxygen into a melt of pig iron from a position below the melt surface. The tubes through which oxygen is injected are each surrounded by a concentric tube through which a shroud or shielding gas is injected.* These tubes, called tuyeres, are shown in the following diagram of a typical Q-BOP converter.

Most patents in this area were granted after 1970. In the most recent three year period, 1975-1977, 32 patents have issued which is 56. 1% of all patenting in this technology in the last decade. The first two graphs on the following page illustrate this growth, first by patent grant date and then by the application date of these patents.

The foreign activity in the Q-BOP process for the period 1975-77 is 65. 6%, almost twice the all technology average of 36%. The country table which follows the graphs shows, by patent grant date and patent application date, the country distribution of the patents in this field that were granted to foreign residents.



Q-BOP (O.B.M.) CONVERTER

Thrust of the Technology

Although the LD or B. O. F. process produces open-hearth quality steel at the rate at which Bessemer steel can be produced while preserving the refractories, the process is not without shortcomings.

The principal problems encountered in B. O. F. practice are associated with the splashing of the melt caused by the violence of the reaction between the oxygen and the impurities of molten pig iron. This creates a great deal of noise and effluent (1, 2). This problem, provided at least some of the impetus to develop a practical process of introducing pure oxygen from beneath the melt, as is done in the Bessemer process.

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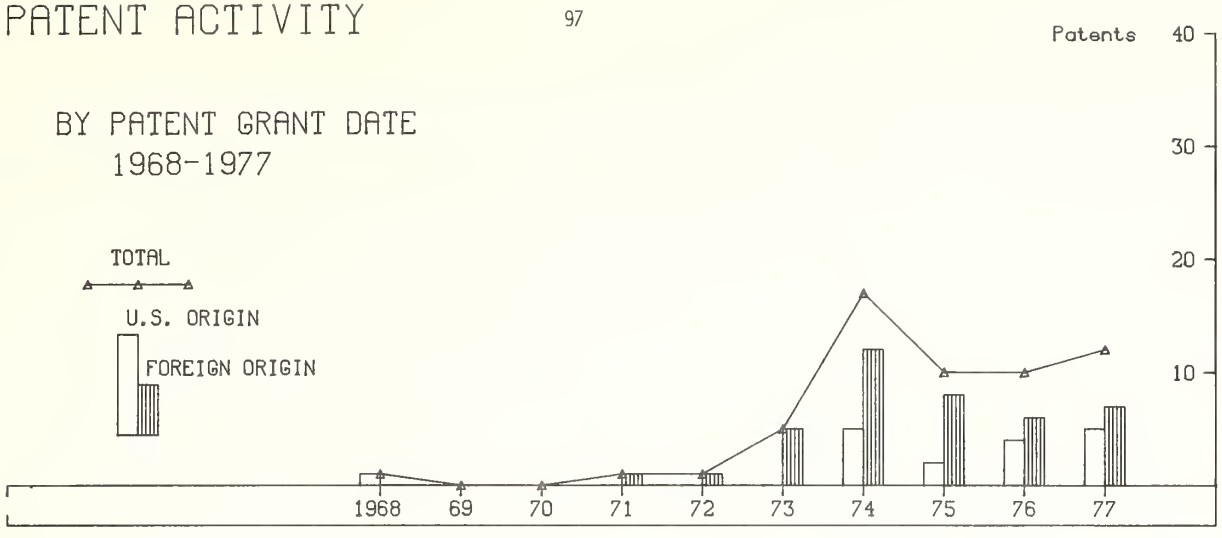
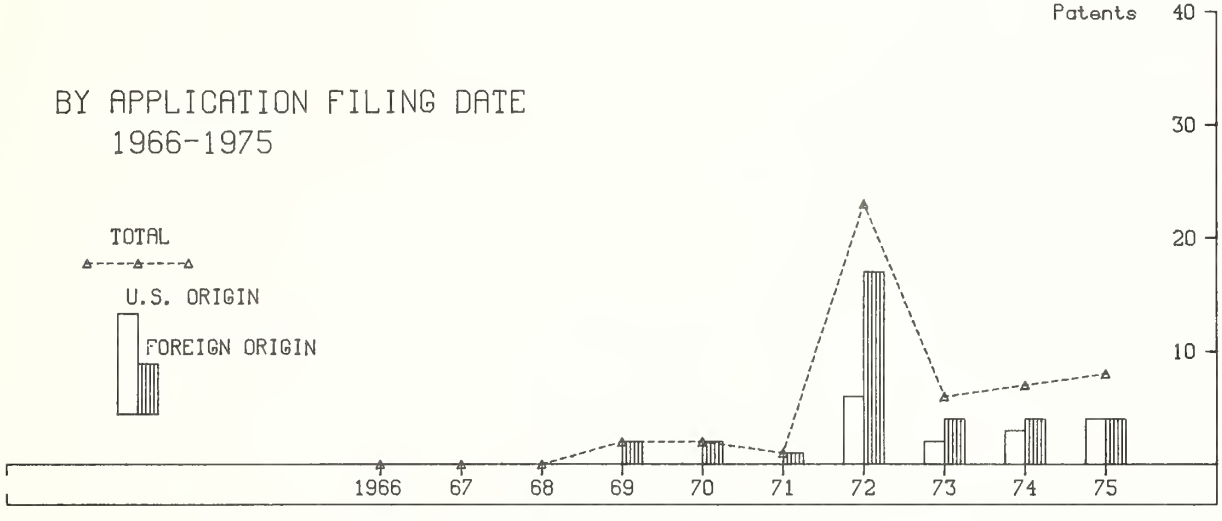
* The Q-BOP or O. B. M. process is classified in Class 75, subclass 60. Apparatus employed to carry out the Q-BOP or O. B. M. process is classified in Class 266, subclasses 245 and 268.

PATENT ACTIVITY





DISTRIBUTION OF PATENTS IN AREA OF INTEREST

	BY PATENT GRANT DATE											BY PATENT APPLICATION FILING DATE										
	1968	69	70	71	72	73	74	75	76	77	TOTAL 68-77	1966	67	68	69	70	71	72	73	74	75	TOTAL 66-75
TOTAL PATENTS	1			1	1	5	17	10	10	12	57				2	2	1	23	6	7	8	49
UNITED STATES	1						5	2	4	5	17							6	2	3	4	15
TOTAL FOREIGN				1	1	5	12	8	6	7	40				2	2	1	17	4	4	4	34
GERMANY					1	3	3	4	2	3	16				2	1	1	5	2	2		13
FRANCE				1		1	5	1	2	3	13					1		6		1	2	10
BELGIUM						1	4	1	1		7							5	1		1	7
SWEDEN								1		1	2								1		1	2
CANADA								1			1							1				1
AUSTRIA									1		1									1		1

Early post World War II efforts to modify the Bessemer process so as to make the introduction of pure oxygen from beneath the surface of the melt feasible centered around (3):

i. mixing the oxygen with a diluent, heat absorbing gas, usually steam or carbon dioxide into the melt;

ii. injecting into the melt from an aperture formed of material having a high heat conductivity;

iii. manipulating the conditions (namely time, temperature, and pressure) under which the oxygen is introduced;

iv. mixing the oxygen with a solid heat absorbing flux, such as lime.

None of the foregoing adjustments of the Bessemer process provided a satistactory solution to the problem of rapid refractory deterioration.

Development of a technique that, in effect, has rejuvenated the Bessemer process has been pioneered by groups working independently in France and at Sulzback-Rosenberg, Federal Republic of Germany. More recently, the United States Steel Corporation has entered the field.

Referred to as the Q-BOP (Q for quiet, because it is less noisy than the LD or OBM process), the crux of the process resides in surrounding each oxygen jet with a separate stream of a shroud or shielding gas. Concentric streams of the encasing gas and oxygen are blown from beneath the melt surface through concentric tube tuyeres). The evolution of the Q-BOP process as revealed in the patent literature will now be traced.

U.S. Patent No. 3,079,249 to de Moustier (patented in February, 1963, filed in the U.S. on February 8, 1960) teaches surrounding each oxygen jet with a separate sheath or shroud of heat absorbing gas. In this patent, the enveloping or encasing gas is characterized as "an auxiliary gas less reactive than technically pure oxygen". The disclosure also teaches entraining in this auxiliary gas stream a flux consisting of oxides and carbonates of alkaline and alkaline earth metals. Claim 5 of the patent reads as follows:

A steel making process which comprises injecting from below into a molten bath of iron jets of technically pure oxygen at a high pressure of at least 20 kg. per sq. cm. and also injecting into said bath around each oxygen jet an annular jet of an auxiliary gas less reactive than said technically pure oxygen and carrying in suspension therein a powdered basic reagent selected from the group consisting of oxides and carbonates of alkaline and alkaline earth metals.

Apparently, the flux was deemed necessary to supply at least part of the cooling effect.

U.S. Patent No. 3,330,645 to de Moustier et al (filed in July, 1963, issued July, 1967) claims inter alia:

> A method for preventing excessive localized erosion of the refractory lining of a metallurgical vessel provided with at least one duct for injecting a fluid into the molten metal contents of said vessel when erosion tends to occur more particularly in an annular zone around the outlet of said injection duct, which method comprises providing around said duct a lining with a large number of channels very substantially narrower than said duct, said channels extending across said lining into said zone which is liable to excessive local erosion, and blowing a protective fluid through said channels into the molten contents of said vessel.

There is disclosed in the specification of U.S. Patent No., 3,330,645 a central duct surrounded by a permeable block. It is taught that a cooling fluid such as water or steam or carbon dioxide or a mixture of steam with carbon dioxide or a combustible gas, such as hydrogen, may be introduced through the permeable block, while oxygen is injected through the central duct. The specification also teaches that pure oxygen may be injected through the pores of the permeable block, while a gas such as air, is injected through the central duct for stirring the melt. This gas may be laden with comminuted solid material, such as lime, which increases the stirring effect.

French Patent No, 1,450,718 (demande July, 1965, delivre July, 1966) teaches the efficiency of employing, as a shroud or encasing gas, a combustible gas consisting primarily of one or a plurality of gaseous hydrocarbons. The specification says nothing about the use of powdered flux.

It is interesting to note that the research leading to the foregoing early patents on bottom blowing with pure oxygen through a composite tuyere was carried out not by an organization concerned with the manufacture of steel, but rather by a maker of industrial gases.

U.S. Patent No. 3,706,549 to Knuppel et al (filed in February 1969 and patented in December, 1972) teaches the next step in the development of the Q-BOP process, namely, flowing the oxygen and the protective fluid in such relative amounts that each injector means is consumed at a rate substantially the same as the refractory lining of the vessel.

Claim 1 reads:

> 1. A method of refining molten metal in a refractory lined vessel comprising:
>
> introducing at least one stream of oxygen through at least one injector extending through the refractory lining of said vessel and having an opening communicating with the interior of the vessel beneath the surface of the molten metal and terminating at the exposed surface of the refractory lining;

protecting said injector and said refractory lining during introduction of oxygen into the molten metal while maintaining the opening of each such injector substantially unobstructed for the flow of

fluid therefrom into the vessel by surrounding each such oxygen stream with a protective fluid containing hydrocarbon in an effective amount up to about 5.8% by weight of the oxygen in each such oxygen stream;

and blowing the oxygen and the protective fluid in such relative amounts within the aforesaid proportions that each such injectory means in consumed at a rate substantially the same as the refractory lining of said vessel.

The specification also teaches:

With a view to the desired slowing down of the reaction of the oxygen with the melt, and because of the cooling effect, the encasing gas should surround the stream of oxygen in the form of a concentric flow. Vapour of a liquid which evaporates at the temperature of the bath may also be blown-in as an encasing or cooling gas. Hydrocarbons, for example, methane, propane, butane, or light oil in the form of vapour may also be blown-in as encasing gases. However, casing gases containing a high proportion of hydrocarbons, such a natural gas or coke-oven gas may also be used.

Most subsequent patents relating to Q-BOP technology fall into one of the following categories:

(i) adaptation of the Q-BOP to charges having specified concentration of impurities, such as, high phosphorus pig iron (4); low phosphorus pig iron (5); at least 20% by weight of steel scrap (6);

(ii) adaptation of the Q-BOP to refine chromium-containing steels (7-9);

(iii) the use of a fluid maintained in the liquid state up to the tip of the tuyere (10, 11);

(iv) the use of tuyeres composed of three concentric tubes (12). A reducing fluid is passed through the inner or central tube and through the outer or peripheral tube, while an oxidizing gas is passed through the middle tube. The function of the reducing fluid emanating from the central or inner tube is to suppress red and brown iron oxide fumes.

(v) adjustments in the disposition of the tuyeres relative to the surface of the melt (13-17);

(vi) varying the pressure or the state (gas/liquid) of the protective medium during the course of processing a heat (18, 19);

(vii) hybridization, that is, the use of concentric tube tuyeres disposed below the melt surface in other types of furnaces, such as, an open hearth (20-22); an electric arc (21,23); and a B.O.F. (LD) converter (24).

(viii) the disposition of composite tuyeres both below the melt surface and in the sidewalls of the converter (25-28);

(ix) the use of bottom blown composite tuyeres in a continuous steelmaking process (29).

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"Bottom Blown Oxygen Gives Steelmaking New Impetus," Iron Age, pp. 41-43 (December 10, 1973).

OFF-GAS TREATMENT

Off-gas treatment refers to the treatment of the effluent or exhaust gas generated in refining iron into steel.*

Patenting in this technology over the past decade has been relatively constant, and at a relatively low level. The first two graphs on the following page illustrates this growth, first by patent grant date and then by the application date of these patents.

Also shown on these graphs is the foreign vs U.S. activity over this time period. For the period 1975-77 the foreign activity averaged 50%, which is substantially more than the all technology average of 36%. The country table which follows the graphs shows, by patent grant date and patent application date, the country distribution of the patents in this field that were granted to foreign residents.

Refining molten pig iron into steel with oxygen results in the evolution of gas and smoke (fume) from the melt surface. This exhaust or off-gas, also referred to as flue gas, is rich in carbon monoxide and entrained (suspended) solid dust particles, the latter accounting for the smoke. The off-gas initially also contains substantial quantities of metal vapors. Solid particles escaping in the exhaust gas initially consist mainly of FeO, Fe_3C, and $FeCO_3$ (1). Upon contact with air these particles and any metal vapor are oxidized, mainly to Fe_2O_3, which has a distinctive reddish-brown appearance. The dust particles, which range in size from 10^{-3} to 10 microns (2), also contain some Fe_3O_4 and a few percent of P_2O_5, SiO_2, MnO, CaO, and other oxides (3).

While all refining processes that involve a reduction in the carbon content of a pig iron melt by reaction with oxygen emit gas and smoke, the problem is particularly acute with the basic oxygen process, due to the injection of pure oxygen and the consequent violence of the reaction between oxygen and carbon and the concomitant evolution of large volumes of smoke and gas at high temperatures (4, 5). Also, in the basic oxygen process, some of the dust particles are of such small size (i.e., below 1 micron) as not to be amenable to removal by a cyclone separator (6).

Theoretically four valuable components are recoverable from the off-gas: (i) the sensible heat of the gas; (ii) carbon monoxide (iii) its heat of combustion; (iv) the iron oxides in the dust particles (7).

In the basic oxygen process, between 70 and 90% by volume of the off-gas is carbon monoxide (8). The temperature of this gas as it leaves the converter mouth is as high as 1430°C (9).

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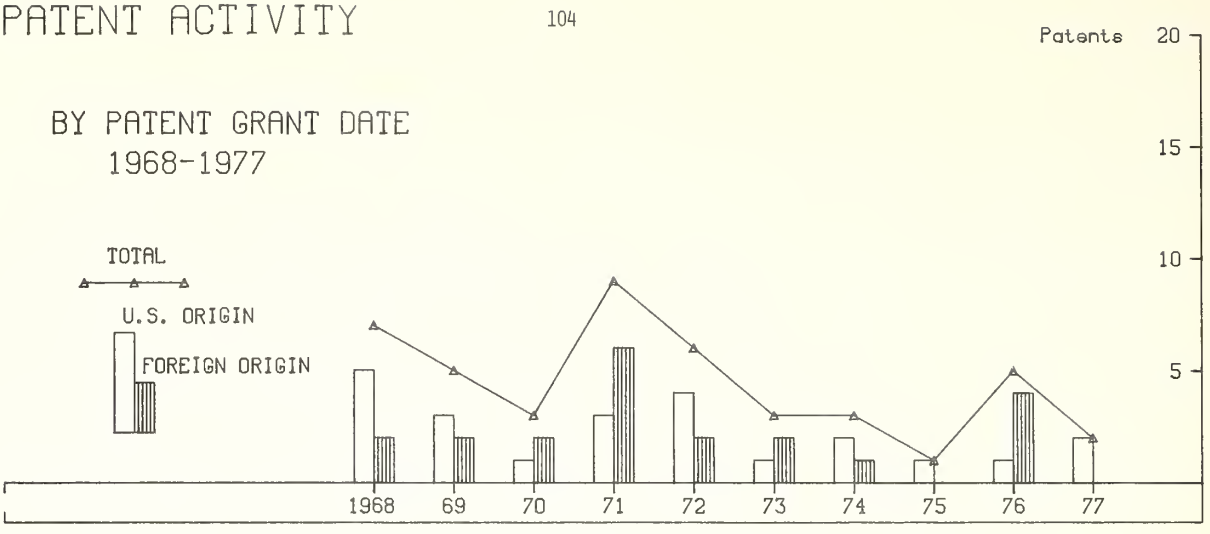
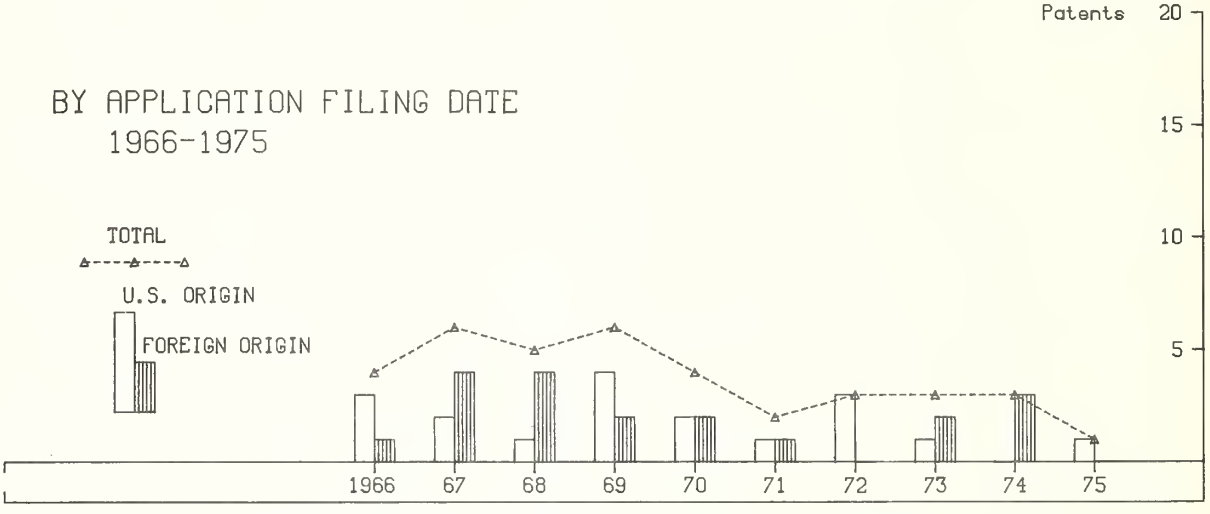
*Procedures for handling and treating off-gas are classified in Class 75, subclass 60. The apparatus to implement such procedures is classified in Class 266, subclasses 144 and 158.

PATENT ACTIVITY

BY PATENT GRANT DATE
1968-1977



BY APPLICATION FILING DATE
1966-1975



DISTRIBUTION OF PATENTS IN AREA OF INTEREST

	BY PATENT GRANT DATE											BY PATENT APPLICATION FILING DATE										
	1968	69	70	71	72	73	74	75	76	77	TOTAL 68-77	1966	67	68	69	70	71	72	73	74	75	TOTAL 66-75
TOTAL PATENTS	7	5	3	9	6	3	3	1	5	2	44	4	6	5	6	4	2	3	3	3	1	37
UNITED STATES	5	3	1	3	4	1	2	1	1	2	23	3	2	1	4	2	1	3	1		1	18
TOTAL FOREIGN	2	2	2	6	2	2	1		4		21	1	4	4	2	2	1		2	3		19
JAPAN	1		1	2	2						6		1	1	2	1						5
GERMANY	1		1	1					1		4	1	1	1						1		4
FRANCE		1									1											
AUSTRIA				1							1		1									1
UNITED KINGDOM				2		1					3			2			1					3
ITALY						1			2		3					1			1	1		3
SWITZERLAND		1					1				2		1						1			2
NETHERLANDS									1		1								1			1

Numerous patents disclose a variety of procedures for recovering one or more of the potentially valuable components of basic oxygen converter off-gas. Many of these procedures also abate pollution (10). Another and most important reason for treating off-gas is to obviate the potential explosion hazard created by large volumes of carbon monoxide at elevated temperature (11, 12).

Off-gas is collected by surrounding the region above and around the converter mouth with a hood while oxygen is being injected. During this interval off-gas is vented from the mouth of the converter into the hood.

Sensible heat can be extracted from off-gas by passing the same through a heat exchanger. Such an operation results in a corresponding reduction in temperature of the off-gas leaving the heat exchanger (13).

It has been proposed to recover both the sensible heat and the heat of combustion of off-gas by adding oxygen in the form of infiltrated air to the off-gas escaping from the converter mouth, the air being stoichiometrically proportioned so as to provide for the complete but controlled combustion of the carbon monoxide. Heat is extracted from the combusted gas by passing the same through a boiler system and then through a dust removing plant before being exhausted into the atmosphere (7). There are also patents which teach directing the off-gas from one basic oxygen furnace into a second basic oxygen furnace so that the heat from the off-gas is utilized to preheat a cold charge (14, 15).

Other procedures for recovering values from the off-gas are predicated upon keeping the off-gas out of contact with the surrounding air. These procedures have the advantage of reducing the possibility of an explosion of the carbon monoxide, and after removing entrained solid dust particles, of recovering carbon monoxide (16) rather than merely its heat of combustion. Such procedures, however, involve an added complication, since the converter must be tilted during charging and discharging. Accordingly, several patents have as their object mechanical sealing means for preventing air from coming into contact with off-gas when the converter is in an upright position, while still permitting the converter to be tilted (17, 18). Other patents propose to keep air out of contact with off-gas by employing what is, in effect, a shroud or curtain of an "inert" gas around the converter mouth (19). The use of steam has been suggested as a shroud (10). It has also been suggested to dilute the off-gas with "inert" gas which is at a lower temperature in order to cool the off-gas to a temperature below its combustion temperature (11).

The conventional procedure for removing suspended dust particles from a stream of off-gas is to pass the same through dust precipitators which usually consist of a water scrubber and electro-static precipitator in series. The water scrubber cools the off-gas and removes the coarser dust particles (2).

It has been estimated that the dust precipitators serving a basic oxygen furnace account for from 18% to 25% of the total cost of the entire installation (20). Consequently, lower cost alternatives have been proposed.

One patent proposes passing the dust laden off-gas over a bed of molten acid silica slag so as to form iron oxide silicate (20). This kind of equipment, the disclosure estimates, will cost only 6% to 12% of the total cost. Another patent teaches removing iron oxides from off-gas by introducing the contaminated flue gas into a heated column of carbonaccous particles having a sufficiently high temperature to reduce the suspended iron oxides to their metallic forms (21). Fumes recovered from off-gas may be recycled either to a blast furnace (22) or to a basic oxygen furnace (23).

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23. 3,948,644	Maurice et al	Pennsylvania Engineering Corp.	U.S.A.

AUTOMATIC CONTROL

Automatic Control involves the use of instruments to sense, measure, and adjust the rate and termination of processing.*

Patent activity for this technology is illustrated in the two graphs on the following page. The first graph presents the data by patent grant date, the second by the application date of these patents.

The foreign vs U.S. activity in automatic controls is also shown on these graphs. For the period 1975-77, the foreign activity amounted to 56%, which is about 1 1/2 times the all technology average of 36%. The country table which follows the graphs shows by patent grant date and patent application date, the country distribution of the patents in the field that were granted to foreign residents.

Since the open-hearth process is relatively slow, samples of a heat may be taken from time to time and chemically analyzed to determine the content of carbon and other impurities. In the Bessemer and oxygen converter processes the conversion of iron to steel is so rapid that there is insufficient time available for taking such samples. Consequently, it was difficult precisely to determine the end point of these processes, that is, the point at which conversion to steel, having the desired composition of carbon and other alloying elements, was complete (1).

Fortunately, there are changes in the nature of the sparks emitted, the sound, and appearance of the flame at the converter mouth as the reaction proceeds (2). During the first phase of the process, when silicon and manganese are being oxidized, there is no flame; during the second phase when the carbon is being oxidized, there is a long flame. When conversion is complete, this flame drops.

The conventional manner of operating the Bessemer process was based upon the melter's experience and perception (3). By eye-measurement of the flame the melter knew approximately when the end point had been reached.

Inherent in this practice were two problems:

1. Exactly when to stop the blow for a desired composition, and

2. Obtaining uniform chemical and physical properties for a series of blows.

The melter's usual reaction to the appearance of the flame was not quantitative and the only standard of comparision was that afforded by his recollection of the behavior of previous heats.

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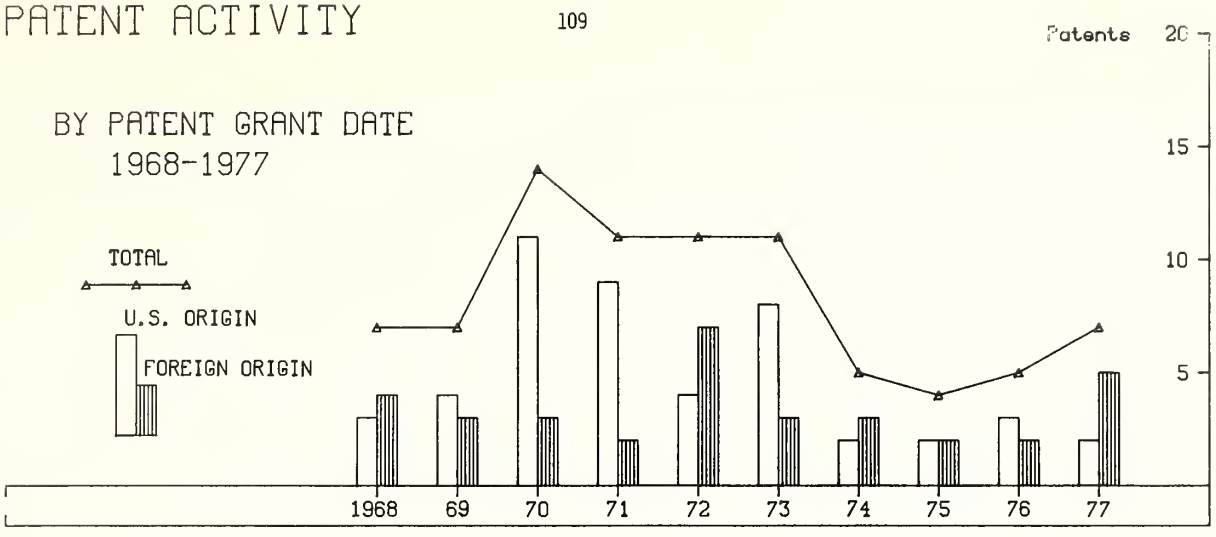
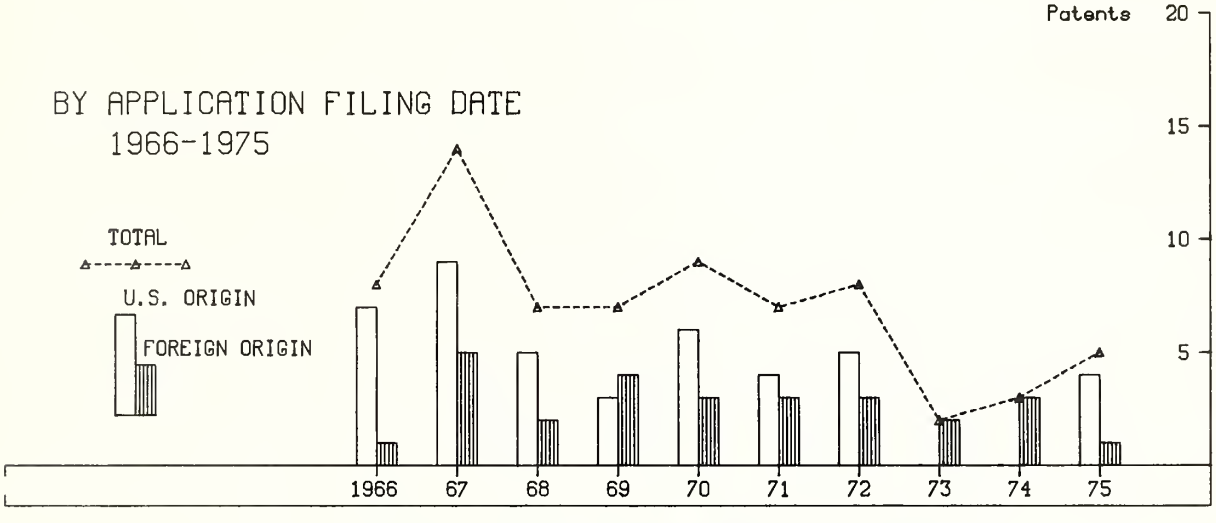
* Methods of automatically controlling the conversion of iron into steel are classified in Class 75, subclass 60. Apparatus for effecting such control is classified in Class 266, subclass 78.

PATENT ACTIVITY





DISTRIBUTION OF PATENTS IN AREA OF INTEREST

	BY PATENT GRANT DATE											BY PATENT APPLICATION FILING DATE										
	1968	69	70	71	72	73	74	75	76	77	TOTAL 68-77	1966	67	68	69	70	71	72	73	74	75	TOTAL 66-75
TOTAL PATENTS	7	7	14	11	11	11	5	4	5	7	82	8	14	7	7	9	7	8	2	3	5	70
UNITED STATES	3	4	11	9	4	8	2	2	3	2	48	7	9	5	3	6	4	5			4	43
TOTAL FOREIGN	4	3	3	2	7	3	3	2	2	5	34	1	5	2	4	3	3	3	2	3	1	27
GERMANY	3	1	1				2	1		3	11	1	1				1	1	1	2		7
JAPAN	1			1	3	1				1	7				3	2					1	6
BELGIUM			2		1	1		1		1	6		3				2					5
UNITED KINGDOM				1	1	1					3			1	1			1				3
ITALY							1		2		3							1	1	1		3
AUSTRIA					1						1					1						1
SWITZERLAND		1									1		1									1
FRANCE		1									1											
HUNGARY					1						1			1								1

To overcome these problems efforts were made to automate the control of the Bessemer process. A light sensitive instrument or photocell was substituted for visual observation. Several patents issued between 1940 and 1957 disclose techniques for utilizing a photometer to measure changes in the light intensity of the Bessemer flame and controlling the blowing based upon similar determinations of previous heat (4-9).

While changes in flame intensity may be employed to control the progress of the reaction in the basic oxygen process (10, 11), because the B. O. F. process generates a great quantity of fume and smoke, it is almost always necessary to provide a flue or hood over the mouth of the vessel to carry away the products of combustion (1). Thus changes in the flame's appearance are obscured and determination of the progress of the reaction by optical measurement has proved less than satisfactory. Consequently control systems based upon other criteria indicative of the end point have been developed.

Among the parameters utilized are: the weight of the melt (12, 13); the apparent weight of the lance (14); sound intensity or vibrations of the converter (15, 16); temperature (17-22); and the composition of the off-gases (18, 23-25).

Early efforts to automate the control of the conversion of iron to steel employed what has become known as "static control." In static control changes in the characteristics of the flame or other parameter, being utilized to indicate the progress of the reactions, are recorded for various starting and final compositions. This data or history of past heats is accumulated. Oxygen is then blown so as to make the characteristics of the parameter being sensed conform to that of a previous heat of similar starting composition to yield steel of the composition desired (15, 26, 27).

More recently, "dynamic control" techniques have been developed. These involve making determinations of the composition of the off-gas and of its mass flow rate, during the progress of a heat, calculating from these data the bath carbon loss, and adjusting the relationship between the rates of carbon removal from the bath and oxidizer input to achieve the desired result (28, 29).

William A. Kolb and Pete Vignovich of the United States Steel Corporation recently have patented a method of dynamically controlling the operation of a Q-BOP converter (30).

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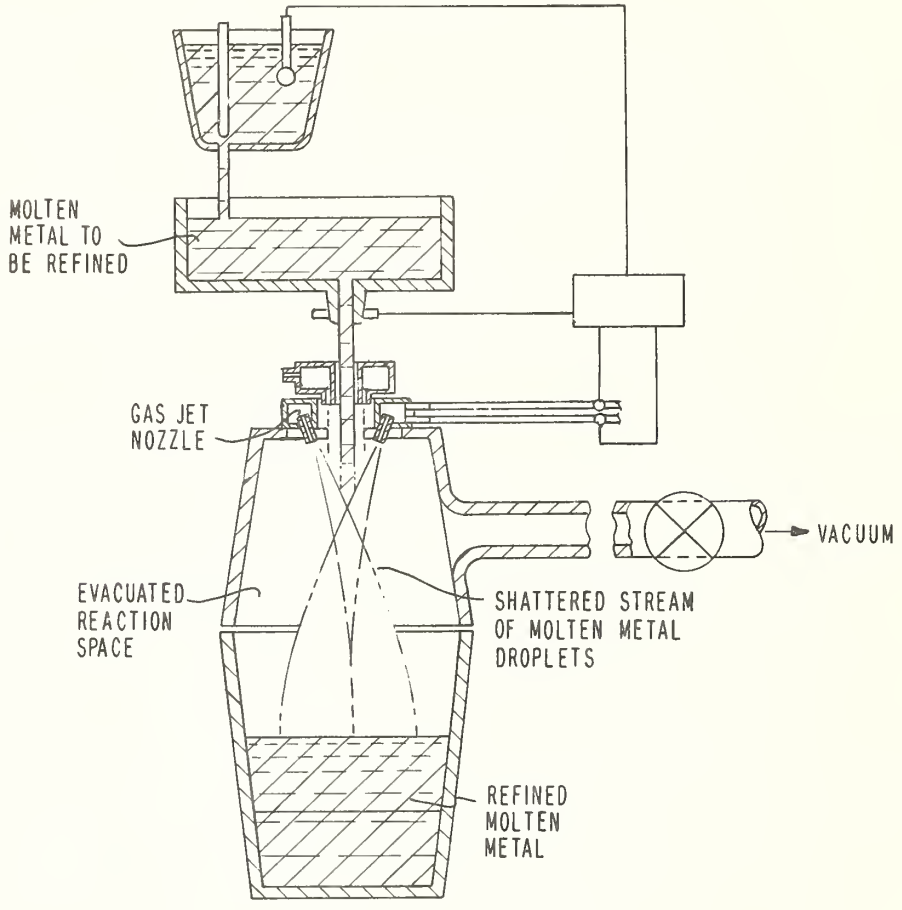
SPRAY REFINING

Spray refining involves the preparation of steel from molten iron that has broken up into a spray or plethora of molten droplets. The purpose of generating a dispersion is to accelerate the rate of reaction between the iron and a treating agent. In the apparatus depicted below the molten metal is transformed into a shattered stream of molten metal droplets by means of a gas jet nozzle.*



SPRAY REFINING

Spray refining is a relatively new process for refining molten pig iron, developed in the United Kingdom.

The basic process involves allowing a stream of molten pig iron to fall freely in a reaction space. Therein the stream is shattered or atomized, so that a spray of droplets of molten metal are formed. The molten metal droplets are contacted with one or more streams of treating agents, such as oxygen and powdered lime.

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*Processes involving spray-refining principles are classified in Class 75 subclass 60. Apparatus for implementing spray refining is classified in Class 266 subclass 202.

In most spray refining operations, the droplets are formed by intersecting the stream of falling molten metal with one or more streams of oxidizing gas (1). However, in one variation of the process, formation of droplets is achieved by allowing the molten metal to descend through a bed of flux which has been packed in a shaft furnace (2). The metal descends as droplets scattered through the flux. Oxidizing gas is introduced through nozzles disposed perpendicular to the downward flow of metal at various heights in the vertical walls of the shaft furnace. The oxygen reacts with the impurities in the pig iron and also agitates the flux-metal emulsion. Slag and gaseous material form as a thick foam which rises in the bed and thus has a flow that is countercurrent to the flow of the descending metal.

A spray refining operation can be conducted such that the reaction space is maintained at reduced pressure (3, 4). Hydrogen and other dissolved gases are thereby sucked out of the falling metal droplets.

In another variation of the spray refining process, molten pig iron is caused to break up into uniformly sized and regularly spaced droplets by subjecting a stream of pig iron to constant frequency vibration (5). Refining is effected by oxygen and a shower of lime particles.

The essential advantage of spray refining techniques is that, because the metal being refined is in a highly dispersed condition, more of it is more rapidly brought into intimate contact with treating agents, thus hastening the refining operation. Consequently, it has been suggested in a number of patents to employ spray refining in continuous steelmaking schemes, coupling it with one or more other stages in the production of steel (6, 7).

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MAKING ALLOY AND HIGH PURITY STEELS

Alloy steels are those containing at least one metallic element in addition to low concentrations of metalloid and gaseous impurities. *

For many specialized applications, the steel produced by even the open hearth or oxygen processes contains unacceptable concentrations of occluded gases and/or solid metalloid inclusions. Moreover, alloying steel with chromium in the open hearth furnace or converter is not feasible without the use of specialized equipment and/or techniques.

Use of electric furnaces, reduced pressure conditions, inert gases, and special fluxes, individually or in combination, have been found necessary to produce specialty steels.

Patenting patterns in processes and apparatus for making alloy and high purity steels is illustrated in the graphs and tables on the following page first by patent grant date and then by the application date of these patents. Over the most recent three year period 30 patents issued in this area.

The foreign vs. U.S. activity is also shown on these graphs. For the period 1975-77, the average yearly foreign activity was 60%, which is considerably higher than the all technology average of 36%. The country table which follows the graphs shows by patent grant date and the application filing date of these patents (patent application date), the country distribution of the patents in the field that were granted to foreign residents.

Production of Chromium Containing Steels

Logically, it would seem that chromium-containing steels could be made simply by adding pure chromium to molten steel. Experience, however, has taught that when pure chromium is added, in either the solid or molten state, to molten steel, the chromium will not be uniformly distributed in the steel bath, but will be segregated from it owing to its viscosity (1).

Chromium can be alloyed with steel by adding the chromium in the form of ferrochromium. However commercial grade ferrochromium, which is produced by smelting chromite ore (mixed oxides of Fe, Cr, and SiO_2, Al_2O_3, and MgO) (2) with carbon, contains unacceptably high levels of carbon (3). Ferrochromium sufficiently free of carbon is prohibitively expensive. Under ordinary conditions, efforts to remove the carbon from impure ferrochrome by oxidation will also remove unacceptably high amounts of chromium, when the chromium level in the melt exceeds 8-12% wt. Under such conditions the chromium will be oxidized in preference to carbon and silicon and chromium oxide will form in a separate slag phase or layer (4-6).

Several techniques have been proposed to overcome the preferential oxidation of chromium.

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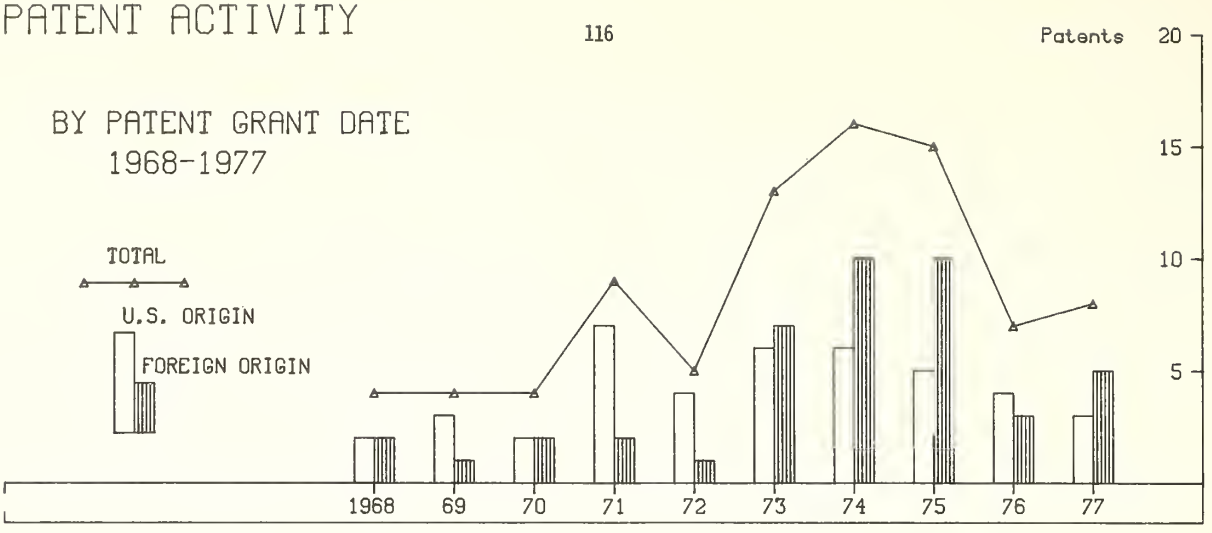
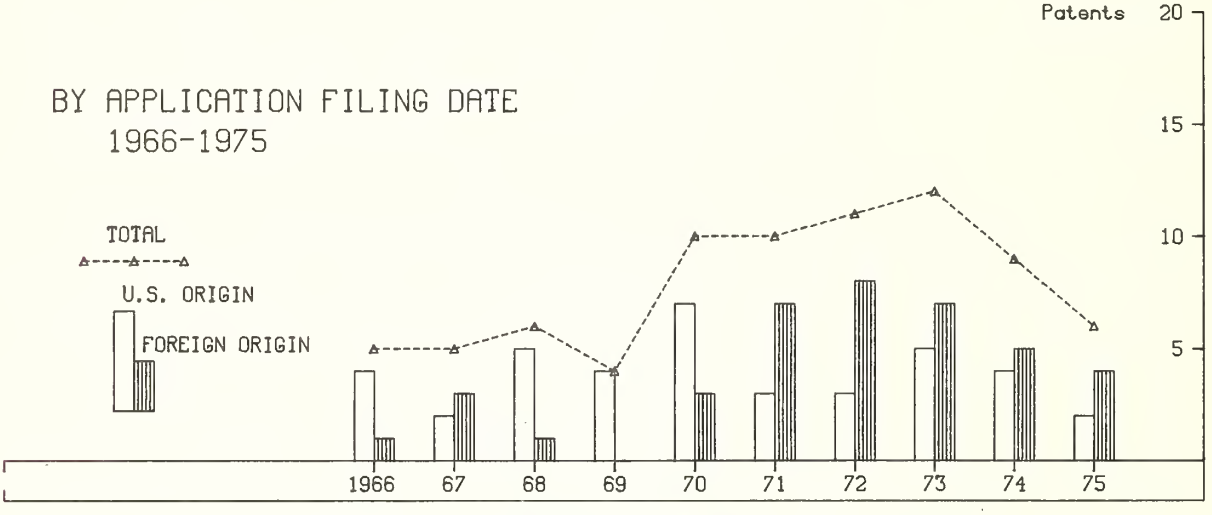
* Processes of making ferrous alloys are classified in Class 75, subclass 129 (stainless steels in Class 75, subclass 130.5). Apparatus employed in alloying is classified in Class 266, subclass 200.

PATENT ACTIVITY





DISTRIBUTION OF PATENTS IN AREA OF INTEREST

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UNITED STATES	2	3	2	7	4	6	6	5	4	3	42	4	2	5	4	7	3	3	5	4	2	39
TOTAL FOREIGN	2	1	2	2	1	7	10	10	3	5	43	1	3	1		3	7	8	7	5	4	39
JAPAN	1			1		3	4		1	2	12		1				1	3	3	1		9
GERMANY		1				2	3	3		1	10	1				1	2	2	1	2	1	10
UNITED KINGDOM	1				1	1	2	1			6					1	3		1			5
SWEDEN						1		4			5					1		2	2			5
FRANCE								1	1		2									1	1	2
FINLAND			1							1	2		1								1	2
ITALY				1					1		2			1						1		2
SWITZERLAND								1		1	2							1			1	2
NETHERLANDS							1				1						1					1
ALL OTHERS			1								1		1									1

a. Slag Manipulation Technique

A conventional method of preparing high chromium steels involves the following steps: (i) Melting a charge containing a source of chromium (usually high carbon ferrochromium); a source of steel (usually carbon steel scrap); and fluxes which will generate an oxidizing slag (viz., a mixture of limestone, fluorspar, and sand). Stainless steel scrap, which is a source both of steel and chromium may also be used. (ii) Injecting gaseous oxygen to oxidize carbon and phosphorus into the molten charge. Mill scale and/or iron oxides may be incorporated in the charge as a/the source of oxygen to oxidize the carbon. (iii) Adding a reducing agent, such as ferrosilicon, to recover iron and chromium from the slag overlying the bath of metal. Along with the reducing agent there is added a desired quantity of basic fluxes including (burnt) lime and fluorspar to assure basic conditions during the reduction of the oxides contained in the slag.

Basic conditions will minimize attack by the acid constituents formed on the furnace lining (6). A variation of this process involves not charging any source of chromium initially, but only a source of iron and fluxes that will generate an oxidizing slag. After the carbon content has been reduced to the desired level, the oxidizing slag is removed and a reducing or basic slag is generated by the addition of lime, fluorspar, and ferrosilicon. Only then is ferrochromium added (7,8). If this approach is used, the ferrochromium must have a carbon content below that of the molten bath because any carbon now entering the furnace will remain in the bath due to the reducing nature of the furnace environment.

b. Operating at Elevated Temperatures

If decarburization is carried out at temperatures about 3500°F oxidation of the chromium will be suppressed (4). However, at such elevated temperatures deterioration of the refractory furnace lining is rapid and thus results in an added cost of production (9).

c. Operating at Reduced Pressure

It has been well known that the formation of chromium oxide is suppressed if either the temperature is raised above that normally used to refine carbon steels (2900-3000°F) (10) to a range of 3100-3600°F or if the oxygen pressure above the slag is reduced (11). Accordingly it has been proposed that pure oxygen be blown into a ferrochrome melt which is maintained in a reduced pressure environment. In such an environment, decarburization can be carried out without excessive oxidation of the chromium. Discussed under the Q-BOP process, is the fact that a Q-BOP type vessel can be operated in a reduced pressure environment in order to effect the decarburization of stainless steel melts without significant loss of chromium to the slag (12).

d. Introducing Pure Oxygen in an Inert Gas Atmosphere (A.O.D. Process)

A practical solution to the oxidation of chromium at atmospheric pressure was discovered by Krivsky of the Union Carbide Corporation (9). Excess carbon is removed from a melt containing iron, carbon, and chromium by introducing oxygen into the molten ferro-alloy until the oxygen begins to oxidize the chromium and then introducing at least one inert gas (such as argon) into the molten ferro-alloy while continuing the oxygen introduction. The inert gas is introduced to an extent that will reduce the partial pressure of the carbon monoxide evolved and in contact with the melt to a level lower than the pressure surrounding the molten ferro-alloy. This process, known as the A.O.D. (A argon, O=oxygen, D=decarburization) is effectively carried out at temperatures as low as 1550°C (2822°F). A patent to Nelson et al, also assigned to the Union Carbide Corporation, teaches an improvement on the Krivsky process involving programmed blowing (13).

An improvement on the A.O.D. process, also patented by the Union Carbide Corporation, involves the addition of controlled amounts of carbon dioxide during refining in order to suppress further the oxidation of metallic elements in the melt (14). A patent to Umowski teaches the decarburization of alloy steels rich in chromium without significant loss of chromium to the slag by injecting oxygen under reduced pressure conditions and then gradually substituting an inert gas for the oxygen until the gas being injected consists entirely of inert gas (15). A patent to Bishop et al, assigned to Allegheny Ludlum Industries Inc. in effect, teaches the use of a combination of an inert or an endothermic gas and reduced pressure to decarburize stainless steel melts in an LD-type converter (16). Here the inert or endothermic gas is introduced from below the melt surface so that the bubbles of oxygen will not become too concentrated with carbon oxides as the reactions proceed. As in the conventional LD process, oxygen is introduced from above the surface of the melt.

e. Uddehelms Process

Recently, Olof Johnsson and Anders Eriksson of Uddeholms Aktrebolog, Hagfors, Sweden have discovered that steam or ammonia can be substituted for at least some of the inert gas employed in the A.O.D. process (17). The steam or ammonia disassociates into their constituent elements under the conditions of the process and act as a diluent of the carbon monoxide formed during decarburization. The Uddeholms process can be carried out in a converter in which composite tuyeres are disposed in the converter bottom (18). A mixture of oxygen and steam, argon, or nitrogen is blown through the outer tube while steam or a mixture of steam and an inert gas is introduced through the inner pipe. Alternatively ammonia is introduced through the inner tube, while the oxygen is introduced through the other tube (19). The chief advantage of the Uddeholms process relative to the A.O.D. process appears to be the utilization of low cost steam and/ or ammonia in lieu of higher cost argon.

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ELECTRIC ARC FURNACES

Non-Consumable Electrode Furnaces*

Electric Arc Furnaces are electric furnaces wherein the heat is generated by means of an electric arc.*

Patenting in electric arc furnaces is illustrated in two graphs on the following pages, first by patent grant date and then by the application filing date of patents issuing in this technology. Also presented is the U.S. vs foreign patenting for each year which shows a steady increase in foreign vs. U.S. patenting in the technology. For the period 1973-75, the foreign patenting averaged 83% which is more than twice the all technology average of 36%.

Following the graphs is a country/company table which shows by patent grant date and patent application date, the country distribution of the patents in this field that were granted to foreign residents.

While stainless steels can be made in an open hearth furnace or in LD- or Q-BOP converters, the furnace of choice is a Heroult-type electric arc furnace. Carbon or graphite non-consumable electrodes create an electric arc between their tips and the charge. The heat generated thereby takes the place of the heat generated by the combustion of fuel and air in the open hearth. A Heroult-type electric arc furnace can also be used to process ordinary carbon steels in lieu of the open hearth furnace or the LD- or Q-BOP converters. However, as electric heat is more expensive than fuel heat, it is seldom used when the added cost does not enhance the value of the product.

When processing stainless steel by operating with first an oxidizing and then reducing slag, the electric arc furnace in generally selected because, as there is no flame in the furnace, it is easier to maintain a suitable atmosphere above the bath and to employ slags that are either oxidizing or reducing (1).

When processing stainless steel by operating at temperatures above 3100° F, the electric arc furnace is generally favored, apparently for the reason that it is smaller than most open hearth furnaces and consequently refractory repair and maintenance is less costly (2).

When processing stainless steel by injecting oxygen under reduced pressure conditions, the general practice is to carry out the process in any one of several types of degassification chambers. Degassification chambers have no external source of heat. Some are equipped with induction coils but these operate at frequencies which effect stirring rather than inductive heating. This equipment will be discussed more fully in a subsequent section.

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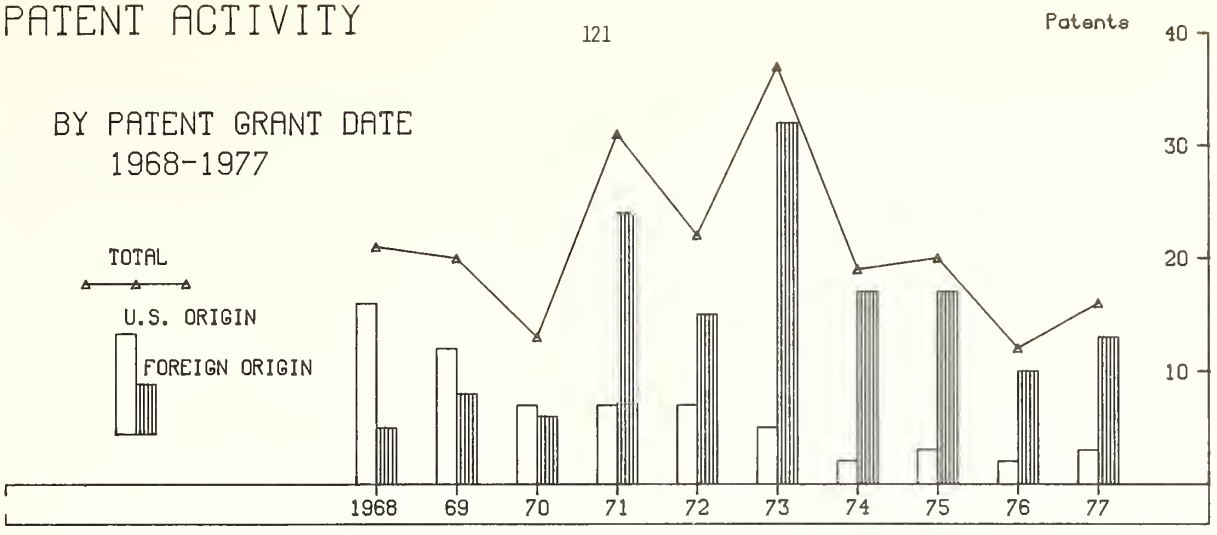
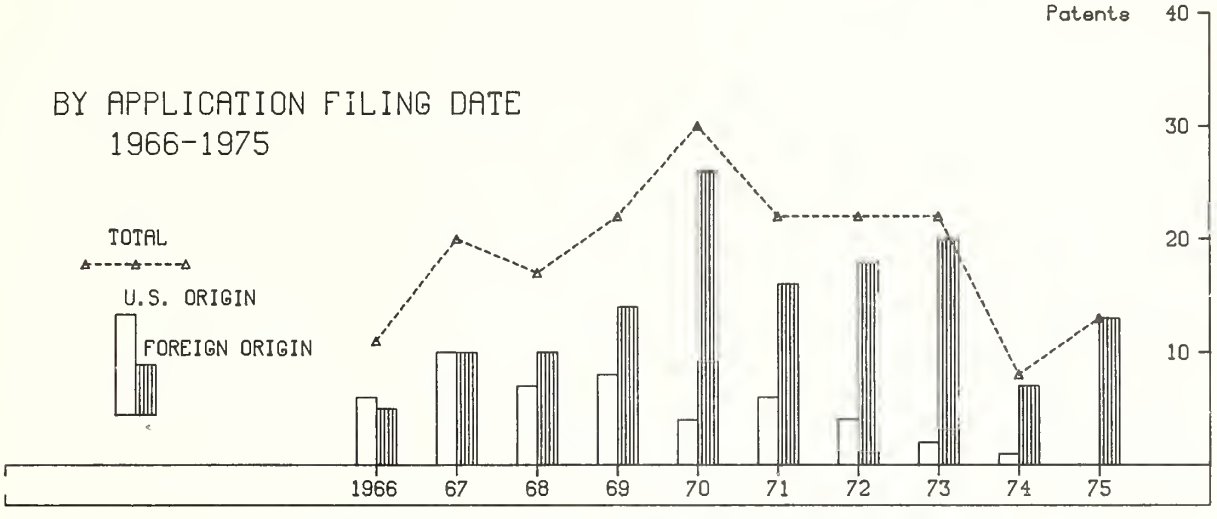
*Methods of making steel in electric furnaces are classified in Class 75, subclass 12. Electric arc furnaces are classified in Class 13, subclass 9.

PATENT ACTIVITY





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TOTAL PATENTS	21	20	13	31	22	37	19	20	12	16	211	11	20	17	22	30	22	22	22	8	13	187
UNITED STATES	16	12	7	7	7	5	2	3	2	3	64	6	10	7	8	4	6	4	2	1		48
TOTAL FOREIGN	5	8	6	24	15	32	17	17	10	13	147	5	10	10	14	26	16	18	20	7	13	139
U.S.S.R.		1	1	4	7	18	11	7	7	4	60		3		4	13	10	11	8	3	6	53
AUSTRIA		1	2	6	4	4				2	19		2	3	3	6		3				17
GERMANY	1		2	3	3	5	1	1	1		17		1	2	2	3	4	2	1	1		16
JAPAN	1	1	1	2		2	3	3		1	14	2	1		2		2		4	2	1	14
UNITED KINGDOM		2		5		1	1	2		1	12		1	4	1	1		1	3		1	12
SWEDEN		1						1	2	2	6	1								1	4	6
FRANCE	1							1		1	3								1			1
BULGARIA				2			1				3					2			1			3
ITALY				1				1		1	3			1					1			2
ALL OTHERS	2	2		1	1	2		1		1	10	2	2		2	1		1	1		1	10

When processing stainless steel by the A. O. D. (argon, oxygen, decarbonization) process, the alloy (substantially at the desired composition with respect to the metallics) is melted in an electric arc furnace and then this melt, after it has been deslagged, is transferred to a refining vessel or converter wherein it is decarburized by subsurface blowing with an inert gas/oxygen mixture.

Another advantage of the electric arc furnace is its ability to facilitate desulphurization. Where a reducing slag containing powdered lime, flourspar, and coke is maintained, sulphur is fixed as calcium sulphide in the slag. The electric arc induces the formation of calcium carbide from the lime and coke and this reacts with the sulphur to form calcium sulphide.

Consumable-Electrode or Remelting Furnaces*

For some applications, steels of extremely high purity are required. Minute amounts of occulded gases and/or solid metalloid inclusions impair qualities needed for critical performance. Remelting a consumable electrode is an effective technique for removing solid metalloid inclusions which impair ductility and fatigue strength. There are basically two forms of remelting: (a) Vacuum arc; and (b) Electroslag. In both techniques a batch of metal to be refined is first either fabricated into an ingot (3) which serve as the consumable electrode or passed in particulate form through the hollow of a tublar nonconsumable electrode (4). An electric current is then passed through the electrode and the heat generated melts the metal to be refined. The refined metal reforms in a water-cooled crucible or mold, also known as a crystallizer.

a. Vacuum Arc Remelting (VAR)

Vacuum arc remelting refers to remelting at extremely low pressures. The vacuum literally sucks out the metalloid inclusions, while drops of metal under the influence of an electric field reform as a refined ingot (5). While either direct or alternating current can be employed, problems are encountered particularly with starting and maintaining an alternating current arc particularly under high vacuum (6).

A modified form of the process employs a separate plasma arc or electron beam (7) to effect the melting of the ingot. Apparently, the extremely high temperatures generated thereby enhances the purity of the product.

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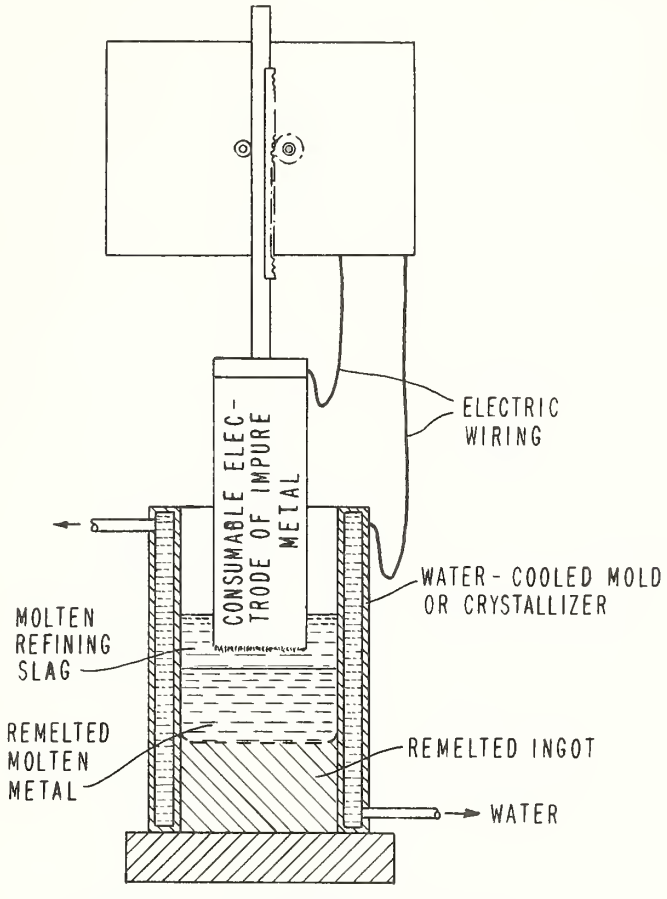
*Remelting techniques are classified in Class 75, subclasses 10-12. If the remelting ingot is continuously formed, these techniques are classified in Class 164, subclasses 50 and 52. Remelting apparatus is classified in Class 13, subclasses 9 and 9ES. If the remelted ingot is continuously cast, the remelting apparatus is classified in Class 164, subclasses 250 and 252.

Vacuum arc remelting was devised in 1905 by Von Bolton, but commercial application did not occur until shortly after World War II (8).

b. Electroslag Remelting (ESR)

Electroslag remelting is carried out at atmospheric pressure. Molten slag instead of a vacuum effects purification. This is shown in the following illustration.

The lower tip of the consumable electrode is immersed in a molten flux or slag, which is contained in a crucible or mold, sometimes also referred to as a crystallizer. When an electric current is passed through the electrode, the electrode begins to melt (3). As drops of molten metal pass through the molten flux or slag, impurities are removed by the flux which is generally composed of fluorspar, calcium oxide, and alumina. The flux exerts a cleansing action on the metal droplets (9). A refined ingot reforms at the bottom of the crucible. While originally regarded as an arc process, the weight of authority now is that, at least after the initial start-up, melting occurs by electrical resistance rather then by electric arc (10). In many systems employing electroslag remelting the refined metal is continuously formed or cast (11).



ELECTROSLAG REMELTING ASSEMBLY

Although the origins of the electroslag remelting process have been traced as far back as the latter part of the last century, Robert K. Hopkins, an American, is generally credited with inventing the process in 1935 (12). A British text on the subject begins by noting that electroslag remelting offers almost a singular example of a process which though invented by an American was extensively developed in the United Kingdom before it was exploited in the United States (13). Indifference to and neglect of the process in the United States has been attributed to a combination of two factors: (i) the reluctance of Hopkins to license his patents; and (ii) the belief among engineers that vacuum arc remelting produced a superior product (14).

Electroslag remelting is a technology in which the Soviet Union has long been active. Soviet development is believed to have proceeded independently of Hopkins work, arising from research on electroslag welding which was initiated after World War II.

One obstacle confronting electroslag remelting practice has been an efficient start-up of the process. A conventional way of introducing slag was to pour premelted slag into the mold from above (15). In such pouring techniques some of the molten slag invariably gets on the crucible walls and the consumable electrode, producing lumps. These fall off into the slag pool during melting and may result in marked variations of electrical conditions of the melting process. Another conventional start up technique involved the use of a starter tablet composed of solid flux (16). Several recent U.S. patents to Soviet inventors apparently solve this problem, by introducing molten slag through the bottom of the crucible, causing it to rise until it contacts the consumable electrode (17-20).

While similarities exist both in regard to the results produced and the means employed in vacuum arc and electroslag remelting, differences do exist in the extent to which each process removes impurities. Electroslag remelting has proven particularly effective in removing sulphur, while hydrogen increase can occur. While vacuum arc remelting does not result in any increase in hydrogen, gas evolution, giving rise to porosity, occasionally occurs (21).

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VACUUM DEGASSING

Vacuum degassing involves subjecting a batch of molten steel to a vacuum environment. The effect of the vacuum being the removal of gases dissolved in the molten steel.*

Patenting in this technology is illustrated in the two graphs on the following page, first by patent grant date and then by the application filing date of these patents. The level of patent filings (graph 2) appear to have peaked in 1970 and declined significantly since that time. An analysis of U.S. vs. foreign patenting in this technology, also shown on the graphs, indicates a dramatic growth in U.S. patenting to foreign resident inventors. In the most recent 3 year period, 1975-77, 67% of the patents issued were to foreigners. This is almost twice the all technology average of 36%.

The table following the graph breaks down the foreign activity into its component parts. Given both by patent grant date and patented application date are the major countries from which these innovations came.

Hydrogen, nitrogen, oxygen and other gases absorbed by molten steel during processing can be removed by subjecting the melt to vacuum conditions. After the melt has been transferred to a ladle any one of several techniques can be employed to effect degassing under reduced pressure conditions.

Ladle degassing merely involves transferring the ladle to a chamber and then evacuating the chamber (1). An inert gas may be injected to agitate the melt and alloying additions may be made while the melt is under a vacuum (2).

Stream degassing is somewhat more sophisticated than simple ladle degassing. Here two ladles are employed: a transfer or tapping ladle and a receiving ladle. The latter is disposed within a vacuum chamber. In practice, an orifice in the bottom of the tapping ladle is brought into communication with an orifice in the top of the vacuum chamber, the receiving ladle being disposed beneath the orifice in the vacuum chamber. When the orifice in the tapping ladle is opened, the melt flows out as a divergent stream and is caught in the receiving ladle while the chamber is maintained at reduced pressure. The downward flow of metal through the vacuum chamber enhances the degassing effect of the vacuum. An inert gas may be injected in the form of bubbles into the molten metal prior to its passage through the orifice to enhance degasification (3).

Another technique employed to enhance the degassing effect of the vacuum is to pour the melt down a flight of refractory brick steps within the evacuated chamber (4).

D-H (Dortmund-Horder) degassing involves the use of a specialized degassing chamber which sucks up the melt through a tubular extension or leg. In practice, the D-H degassing chamber is brought over a ladle of the melt that is to be degassed. The chamber is then lowered until the

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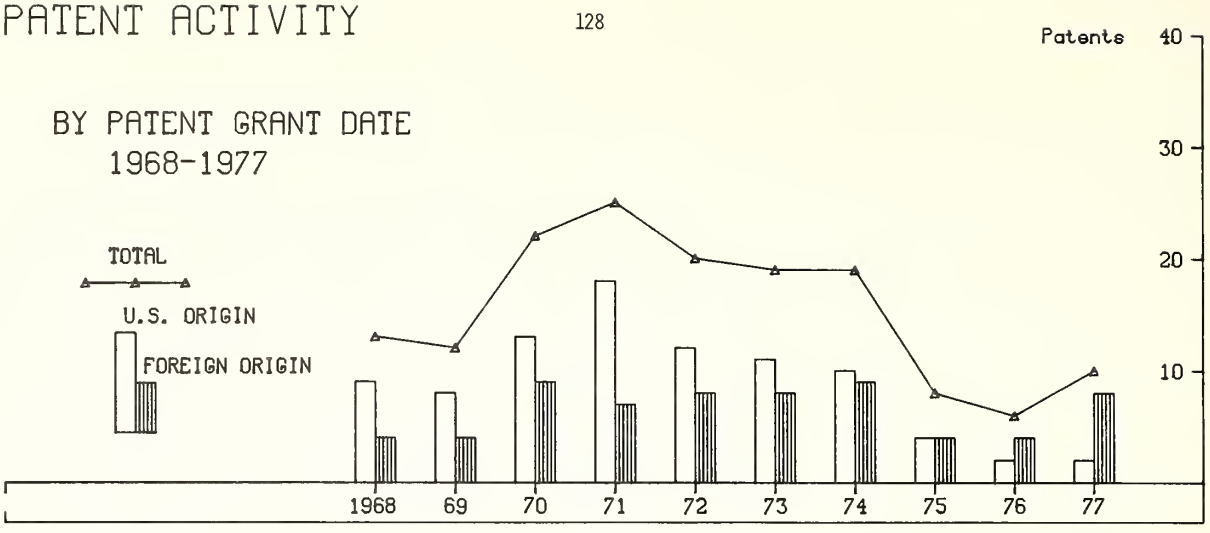
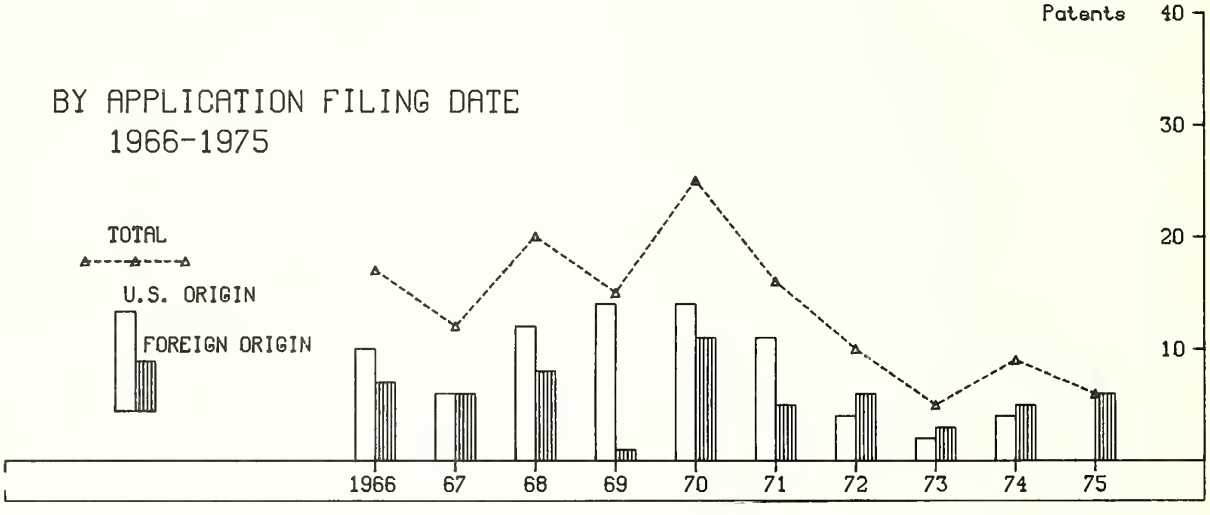
*Methods of vacuum degassing are classified in Class 75, subclass 49. Vacuum degassing apparatus is classified in Class 266, subclass 208.

PATENT ACTIVITY





DISTRIBUTION OF PATENTS IN AREA OF INTEREST

	BY PATENT GRANT DATE											BY PATENT APPLICATION FILING DATE										
	1968	69	70	71	72	73	74	75	76	77	TOTAL 68-77	1966	67	68	69	70	71	72	73	74	75	TOTAL 66-75
TOTAL PATENTS	13	12	22	25	20	19	19	8	6	10	154	17	12	20	15	25	16	10	5	9	6	135
UNITED STATES	9	8	13	18	12	11	10	4	2	2	89	10	6	12	14	14	11	4	2	4		77
TOTAL FOREIGN	4	4	9	7	8	8	9	4	4	8	65	7	6	8	1	11	5	6	3	5	6	58
GERMANY	4	2	8	6	1	3	3	3	1	2	33	5	5	5		4	2	2	1	3	1	28
JAPAN		2					2		2	3	9	2				1		1		1	3	8
FRANCE					1	2	2			1	6			1			2	2			1	6
SWEDEN							1	1			2								2			2
UNITED KINGDOM			1		1						2		1			1						2
U.S.S.R.					1	1				1	3					1		1			1	3
SWITZERLAND						1					1					1						1
AUSTRIA					1				1		2					1				1		2
BELGIUM					1						1					1						1
ALL OTHERS				1	2	1	1			1	6			2	1	1	1					5

nozzle of the leg is submerged beneath the surface of the melt in the ladle. Suction within the ladle is then turned on and the melt rises into the degassing chamber where it is subjected to extensive mixing (5). Alloy additions may be made within the chamber.

R-H (Ruhrstahl-Heraeus) degassing involves the use of a degassing chamber which is provided with two tubular extensions or legs. One leg is provided with an inlet for the injection of an inert gas. The legs of the R-H degassing chamber is lowered in to the melt, and suction applied. Injection of inlet gas into one leg causes melt metal to rise in that leg and return to the ladle through the other leg. This causes a continuous circulation of metal from the ladle into the R-H chamber and back to the ladle. Circulation of the melt within some R-H type degassification chambers may be further enhanced with induction coils. These generally operate at frequencies of the order of 0.5 to 2 Hz in order not to permit any heating by the Joule effect (6). The induction coil may be disposed around the body of the degasification chamber (7) or around one of the chamber's legs (8).

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SOLID TREATING AGENTS

Solid treating agents are substances added to molten iron or steel in order to facilitate and/or effect the removal of impurities. *

Most patenting in solid treating agents has occurred in recent years. For the most recent three year period, 1975-77, 93 patents have issued. This is 50% of all patenting in this technology in the last decade. The first two graphs on the following page illustrate this growth, first by patent grant date and then by the application date of these patents.

The foreign activity in solid treating agents was higher than the average for all technology. For the period 1975-77 it amounted to 58% of all patents issued, which is about 1 1/2 times the all technology average of 36%.

The country table which follows the graph shows by patent grant date and patent application date, the country distribution of the patents in this field that were granted to foreign resident inventors.

Solid treating agents serve a wide variety of functions in the making of steel.

Compositions which facilitate fusion of gangue or other refractory components of a charge are referred to as fluxes (1). Such compositions also enhance the separation of the metallic from the non-metallic components (2). Some confusion exists in the literature between the terms "flux" and "slag". Properly speaking the term "slag" should be reserved for the non-metallic phase generated during processing, whereas, the term "flux" should be used to describe non-metallic compositions added to facilitate the generation of a discrete non-metallic phase (3). Sometimes, however, the term "slag" is used to describe compositions to be added to a charge to facilitate reduction or refining. Fluxes generally consist entirely of physical mixtures of inorganic oxides and/or salts, and are broadly divided into two groups: acidic and basic. Generally, basic ores are fluxed with acidic fluxes and acidic ores are fluxed with basic fluxes (3). Silica (SiO_2) is an example of a substance that exhibits acidic properties, while lime (CaO) and other calcium-containing compounds, namely, limestone ($CaCO_3$) and dolomite ($MgCO_3$, $CaCO_3$), are examples of substances that exhibit basic properties (4). The so-called V-Ratio=%wt CaO/% wt SiO_2 is frequently used as an indicia for comparing the basicity of slags (5).

In refining operations the non-metallic constituents are metalloid impurities, dissolved gases and metal oxides formed by the refining operation. Solid treating agents may be employed to remove metalloid impurities and/or dissolved gases. They may also be used to prevent surface oxi-

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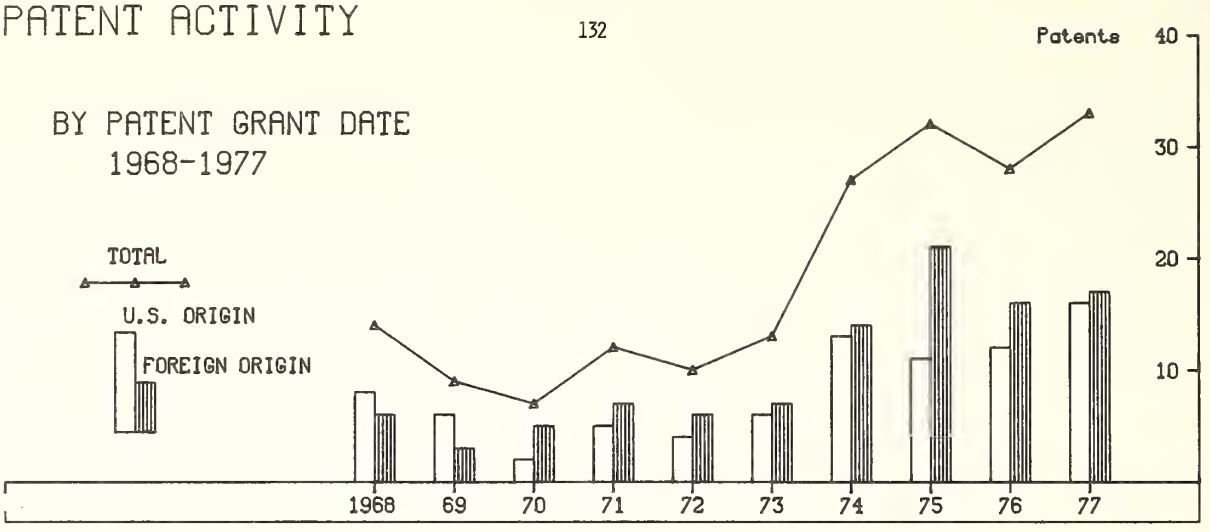
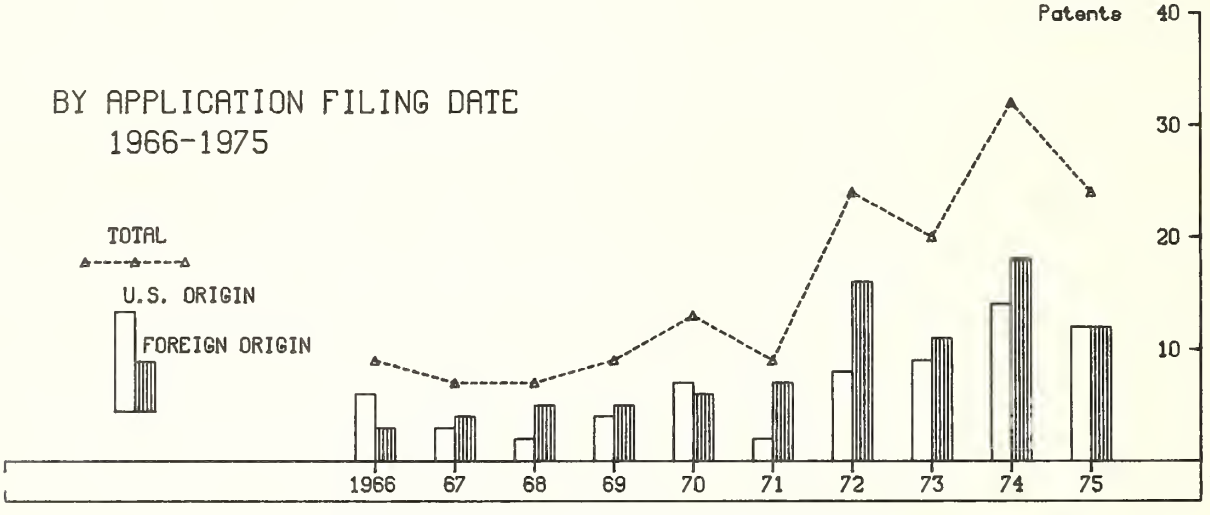
*Fluxes employed in the reduction of metal (whether ferrous or nonferrous) are classified in Class 75, subclass 257. Refining fluxes (solid treating agents) are classified in Class 75, subclasses 51-58. Capsules and packages used to introduce solid treating agents into molten metal are classified in Class 75, subclass 93G. Apparatus for introducing solid treating agents is classified in Class 266, subclasses 216 and 217.

PATENT ACTIVITY





DISTRIBUTION OF PATENTS IN AREA OF INTEREST

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TOTAL PATENTS	14	9	7	12	10	13	27	32	28	33	185	9	7	7	9	13	9	24	20	32	24	134
UNITED STATES	8	6	2	5	4	6	13	11	12	16	83	6	3	2	4	7	2	8	9	14	12	67
TOTAL FOREIGN	6	3	5	7	6	7	14	21	16	17	102	3	4	5	5	6	7	16	11	18	12	87
JAPAN				2	3	2	4	9	6	7	33			2	2	2	2	5	7	2	7	29
GERMANY		1		4		2		6	4	2	19			1	2	1	2	1	1	7	1	16
UNITED KINGDOM	1	1	1	1	1	1	2	1	2	4	15	1	1	1		1	1	2		4	2	13
FRANCE	3	1			1			2	1	1	9	2			1			1	1	2		7
SWITZERLAND			2			1	2		1		6		2					3			1	6
NETHERLANDS			2		1		1	1			5		1	1		1		1	1			5
SWEDEN	1						1		1	1	4							1		1	1	3
ITALY							1	1		2	4						1			1		2
SPAIN	1					1					2					1						1
ALL OTHERS							3	1	1		5						1	2	1	1		5

dation or to hinder the volatilization of low-melting metals during alloying processes (6). Such compositions, which are generally also composed of physical mixtures of inorganic oxides and/or salts, may be referred to as (refining) fluxes. They perform a fluxing function in that they promote the separation of metallic and non-metallic constitutents. The term scavenger has been used in regard to compositions that effect the removal of dissolved gases from molten metal, although this term has also been used in regard to compositions that remove metalloid impurities.

It is known to employ solid treating agents to remove sulphur and phosphorus.

The preferred method of desulphurizing molten steel is to treat a melt with a metallurgical conditioning slag. The main factors promoting desulphurization of the metal by the slag are: (i) a high slag basicity; (ii) low temperature; (iii) reducing conditions, and (iv) high carbon, silicon and phosphorus in the metal (7).

A number of recent patents relate to desulphurizing with solid treating agents. Calcium and calcium-containing compounds, particularly calcium carbide (CaC_2) are well known desulphurizers (8). Recent patents disclose particular calcium-containing compositions and/or techniques for achieving more effective desulphurization.

For example, one recent patent teaches effective desulphurization can be achieved by employing calcium carbide particles of a specified size that are injected at a specified velocity and to a specified depth within the melt (9).

Another recent patent teaches desulphurizing pig iron melts with a particulate fluidized mixture of magnesium and a non-oxidizing material (such as lime) sized so that about 80% of its particles are smaller than about 100 microns (10).

Still another recent patent teaches desulphurization in a ladle having a refractory lining of a specified composition by injecting, at least 2,000 mm below the melt surface, a finely divided calcium-containing compound after a basic-slag layer is applied to the surface of the deoxidized steel melt. The melt is to be held at a temperature of at least 1,530° C during desulphurization (11).

Yet another recent patent teaches a process of desulphurization involving the use of metallic calcium and a reduced pressure environment in addition to the maintenance of a basic slag and the subsurface injection of the treating agent (12).

Several general techniques are employed for introducing the desulphurizing agent: (i) stirring a desulphurizing agent such as calcium carbide into the metal; (ii) plunging desulphurizing agents, such as magnesium impregnated coke under the surface of the molten metal and (iii) injecting desulphurizing agents, such as lime, calcium carbide, or calcium cyana-

mide, by entraining particles thereof in an inert gas (13). Some recent patents disclose what purport to be more effective capsule-like structures to be plunged into a melt (14).

Certain metals and metalloids in their elemental or uncombined state have been employed to deoxidize ferrous melts. These elements act as reducing agents displacing iron that is combined with oxygen. Magnesium, aluminum, titanium, the rare earths, silicon, and carbon are conventional deoxidizers (15). These same elements also may be employed to form ferrous alloys. Generally, before any alloying occurs enough of the element must be added to effect deoxidization. Certain compounds containing a reactive element are also effective deoxidizers as, for example, silicon carbide (16).

Just as certain substances may function both as a deoxidizer and an alloying element, so too may the same substance effect the removal of more than one impurity. For example, magnesium acts as both a desulphurizer and as a deoxidizer (16). The same is true of many other substances. Lime (CaO) serves a variety of functions. It acts as a dephosphorizer as well as a desulphurizer (17). It increases the basicity of the slag and facilitates the necessary chemical reactions between the slag and the impurities in molten metal, particularly carbon, sulphur, manganese and phosphorus (18). Titanium removes nitrogen as well as oxygen (19).

As already noted, most solid treating agents are physical mixtures of two or more substances. Some of the ingredients employed in patented treating agent compositions have a generally predictable effect upon the overall performance of the mixture. For example, it is known that fluorides, and particularly calcium fluoride, tends to increase the fluidity of a slag (20). What the ingredients will be and the relative proportions of each will be, is dictated by a combination of chemical and economic considerations. For example, it is well known that elemental magnesium and calcium carbide are effective desulphurizers. However, magnesium reacts violently when introduced into molten iron. Consequently, it has been suggested to mix or dilute the magnesium in a carefully defined manner with lime - a less reactive desulphurizer (21). The high cost of calcium carbide and its tendency to react with water to generate easily inflammable acetylene was the motivation for a composition containing lime and certain alkaline or alkaline earth metal fluorides (22).

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MAKING CAST IRON AND CAST STEEL ALLOYS

Cast iron or steel generally refers to ferrous articles whose final form was created by pouring molten iron or steel into a mold whose shape corresponds to that of the finished article.*

Finished products composed of metal are fabricated in one of two general ways: (i) an ingot or block of metal is mechanically worked into the desired, final shape; or (ii) the final shape is formed by casting, i.e., by pouring molten metal into a mold.

Most steel mills not only produce steel ingots but also fabricate the ingots into certain basic shapes (sheets, wire, billets, tubes, plates). Castings, on the other hand, are generally not made at the steel mill, but rather in separate plants, known as foundries. As each casting requires its own individual mold, fabricating a finished shape by casting is generally more expensive than making it by mechanical working.

MAKING CAST IRON

For many applications employing ferrous castings the iron is alloyed with 2% by wt. and upward of carbon (generally 2-4%). Such ferrous alloys are not classified as "steel", but rather as "cast iron" (1). The properties of cast iron are a function not only of the alloying elements (generally carbon and silicon) and the proportions thereof, but also of the process by which the cast iron is made (2). Each type of cast iron has a characteristic microstructure.

There are three basic forms of cast iron: gray, white, and mottled.

In gray cast iron the carbon exists as graphite; in white cast iron the carbon is in the form of iron carbide; whereas in mottled cast iron the carbon is present partly as graphite and partly as iron carbide (3). Malleable cast iron is made by annealing white cast iron (4).

Gray cast irons are relatively soft and machinable, while white cast irons are relatively hard and brittle (3).

There are several forms of gray cast iron. On the microscopic level, these forms differ in the shape of the graphite particles dispersed in the iron matrix. Cast iron in which graphite is present in the form of flakes possesses comparatively poor mechanical properties being weak, soft, and brittle (5). Cast iron in which graphite is present as nodules or spheroids, known as nodular or spheroidal (gray) or ductile cast iron, possesses superior mechanical properties, including enhanced strength, toughness, and ductility (6).

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*Processes of making alloys in general are classified in Class 75, subclass 129. Processes of making cast iron are classified in Class 75, subclass 130. Apparatus for alloying is classified in Class 266, subclasses 219 and 900.

Somewhat more than thirty years ago Millis, Gagnebin, and Pilling, all of the International Nickel Company, discovered that cast iron could be consistently and reproducibly manufactured into castings in which the uncombined carbon was present in spheroidal or nodular, rather than flake form (6). In essence, nodular cast iron is produced, according to the teachings of Millis et al, by introducing magnesium into a batch of molten cast iron in an amount sufficient to provide about 0.035% to about 0.5% by wt. retained magnesium in castings poured from the batch. This small amount of magnesium is retained in the castings under proper conditions to effect the occurrence of uncombined carbon in a spheroidal form in the as-cast condition.

The essential steps in making nodular cast iron are: (i) melting pig iron and/or steel scrap in a melting furnace; (ii) transferring the melt to a ladle; (iii) subjecting the melt to a desulphurizing treatment, usually within the ladle; (iv) adding a nodularizing agent; (v) inoculating the melt with ferrosilicon or other silicon containing alloy; and (vi) casting the melt by pouring it into a mold and allowing it to solidify (7). Much of the iron used in casting is melted in a furnace known as a "cupola", which structurally is a miniature blast furnace. Inoculation generally refers to the step of introducing a silicon-containing compound, usually ferrosilicion, just prior to casting, in order to inhibit the formation of iron carbide (3,8). It should be noted that while the term "inoculating" generally refers to treatment of a melt with a silicon-containing alloy for the purpose of inhibiting the formation of iron carbide, the term has also been used in regard to the addition of a nodularizing agent (9,10). The passageway between the mold itself and the exterior of the mold through which molten metal will be introduced is known as the "gate" or "gating system".

Several elements other than magnesium have also been found to effect the nodularization of cast iron, namely, cerium and other rare earths, calcium, tin, strontium, selenium, barium, bismuth, tellurium, and zirconium (11,12).

A problem confronting the industry has been retention of the nodularizing agent in the melt. Magnesium and other nodularizing agents do not dissolve in iron in appreciable amounts. The direct addition of the nodularizing agent in elemental form produces a violent reaction which culminates in its violent oxidation, with evolution of thick clouds of white smoke (13). This is known in the art as "flare" and the accompanying loss of magnesium is generally referred to in the art as "fading" (14). Both are undesirably-flare from an environmental viewpoint; fading from an economic standpoint.

It was found that flare and fading could be reduced by adding the nodularizing element(s) as an alloy of iron, ferrosilicion, nickel, or copper. Several additional techniques have been developed further to reduce flare and fading. One of these techniques involves placing the nodularizing

alloy on the bottom of the ladle and then pouring molten pig iron onto it. A further refinement, known as the "sandwich method" involves placing steel scrap over the nodularizing alloy before introducing the molten pig iron (15).

Another technique of introducing magnesium into molten pig iron is to entrain magnesium particles in a gaseous stream and inject the magnesium thus entrained into the pig iron (16).

An even more effective procedure, which practically eliminates flare and fading, involves placing the nodularizing alloy directly into an intermediate cavity within the casting mold itself, rather than adding it to molten pig iron before it is poured into the mold (17). The molten pig iron picks up and dissolves the nodularizing alloy as it flows through the intermediate cavity. This process, which is often referred to as "inmold" nodularization or treatment, eliminates many of the problems previously encountered, but due to the turbulent flow conditions in the chamber the nodularizing agent tends to dissolve nonuniformly and a significant amount of dross is usually formed, which can cause "dirty" castings. In order to reduce dross, the "inmold" nodularization process generally requires preliminary desulphurization of the molten iron. Castings produced according to the "inmold" process also require special inspection techniques such as ultrasonic inspection and destructive sampling (18). Other problems still remaining include the likelihood of (i) defects in the casting resulting from undissolved or nonuniformly mixed particulate nodularizing agent which has floated or has been cornered into the cavity; (ii) variable segregation of the alloy or a variable solubility rate causing a metallurgical variation in the casting; (iii) unnecessary waste resulting from expansion of the volume of the gating system to accomodate the particulate matter; (iv) the inability to closely target the minimum amount of magnesium to obtain complete or partial nodularization; (v) slag defects in the casting resulting from the greater surface oxidation of the selected nodularizing agent used in particulate form; (vi) the inability to remove the alloy from unpoured molds thus deteriorating the molding properties of the sand mixture in the unpoured molds (19).

RHEOCASTING

Rheocasting is the name that has been applied to a new die casting technique developed by Professor Merton C. Flemings and his colleagues at the Massachusetts Institute of Technology.

The process is characterized by the casting of semi-solid metal. The advantages of rheocasting include sounder castings and prolonged die life. Because the melt has been cooled somewhat and is partially solidified when casting occurs, less damage is done to the die than in conventional die casting.

Molten metal is vigorously stirred as it is cooled such that solidification begins to occur as the formation of little spheroids within a matrix of molten metal. While the metal is in this slurry-like state, it is cast. The technique is applicable to non-ferrous as well as to ferrous alloys (20-23).

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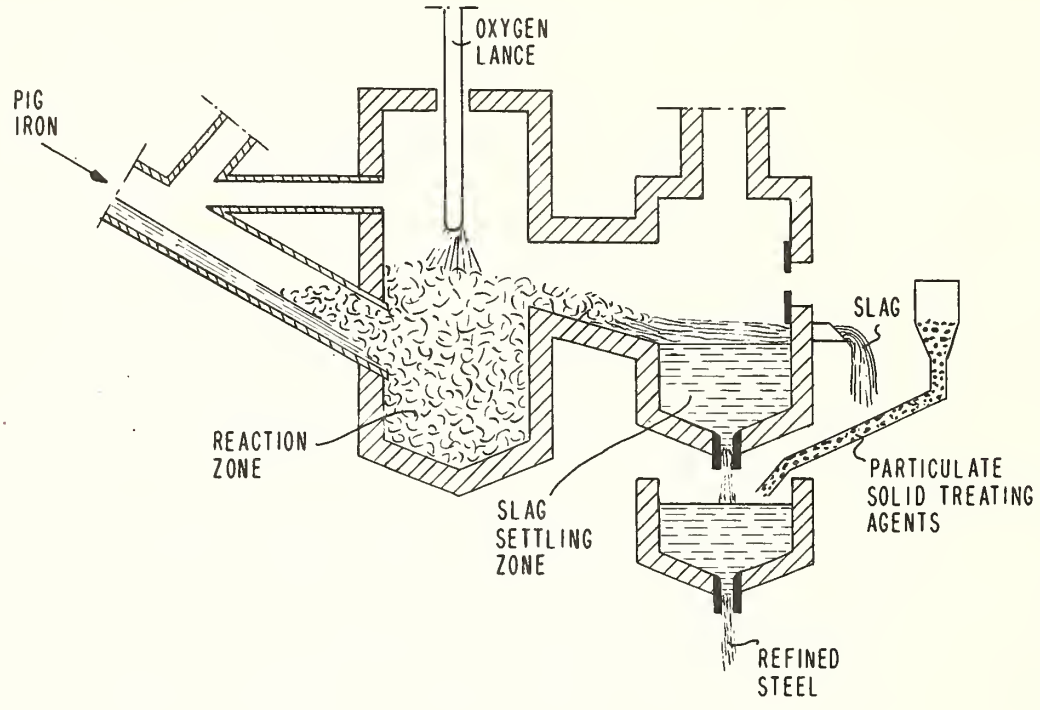
CONTINUOUS STEELMAKING

The term continuous steelmaking* is generally reserved for processes whereby molten pig iron is continuously introduced and molten steel is continuously withdrawn (1). ** A multi-zoned continuous steel making apparatus is shown in the following figure.



CONTINUOUS REFINING
OF PIG IRON INTO STEEL

It has already been mentioned that steel is the product of essentially a two stage process. In the first stage, iron oxide is reduced to metallic iron that is rich in carbon and other metalloid impurities, while in the second or refining stage these excess impurities are removed by oxidation to the extent necessary to meet specifications set by customers. The product of the refining operation is cast as ingots which are then physically manipulated into usable shapes: (i) either mechanically, as by rolling into sheets or bars or by drawing into wire; or (ii) by first melting at a foundry and then casting into final form.

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*Continuous steelmaking processes are classified in Class 75, subclasses 46 and 60 except those that employ electric furnaces exclusively, which are classified in Class 75, subclasses 11 and 12. Apparatus used in continuous steelmaking is classified in Class 266, subclasses 161 and 215.

**A truly continuous steelmaking operation would be even more comprehensive, beginning with a continuous feeding of iron oxide and other reactants and ending with the continuous production of steel in the desired shape and form.

Standard practice is to operate the blast furnace essentially continuously. While molten pig iron does not continuously flow from the blast furnace, the furnace is not allowed to cool and is either being charged or is smelting a charge or is being tapped. Most pig iron removed from the blast furnace is not allowed to solidify. Rather the molten or "hot metal" is immediately transferred to insulated torpedo-shaped railway cars wherein it is transported to a refining vessel. Making steel from such hot metal saves energy. Sometimes, however, this is not feasible and pig iron must be stockpiled. This is done by pouring the molten iron into molds and allowing it to solidify. These pig iron castings are referred to as "pigs".

The molten steel product is poured into a series of separate ingot molds or is continuously cast into a bars or other standard shapes.

Because molten pig iron, scrap, and other reactants are not continuously supplied and steel not continuously removed from either the open hearth or any of the converter-type furnaces, these steelmaking processes are characterized as intermittent or batch processes. A batch of steel is often referred to as a "heat".

Two types of obstacles have stood in the path of such a continuous operation: (i) economic considerations; (ii) technological problems.

Economic considerations arise out of the need for steel products of many different grades and shapes. The demand for any one type of steel is finite and limited. Steel companies do not and could not afford to stockpile a large inventory of steel in many different grades and shapes and await or even solicit orders therefor. On the contrary, the practice is to make steel only after an order has been received. Obviously, such a manner of doing business does not lend itself to a continuous operation (2).

In general, the technological obstacles confronting a continuous steelmaking operation on a commercial scale arise from the stresses brought to bear upon the equipment and upon the environment by continuous processing. Also, the reaction between the metalloid impurities and oxygen must be sufficiently rapid and/or the reaction zone must be sufficiently large to remove these impurities to the extent desired from a continuous flow of material.

A number of patents propose schemes for continuously making steel from molten pig iron. Most of these processes envision the use of at least two chambers or compartments, disposed either as distinct but connected vessels (3) or as a single vessel partitioned by one or more partial physical barriers into regions or zones, such that the compartments are in physical communication with one another (4). A stream of hot metal continuously pours into the first chamber (refining zone) and oxygen is injected into the molten metal. In the second chamber (decantation zone) there is a settling and separation of the slag and molten steel (5).

Variations include the use of multiple refining zones, oxygen being injected from different directions in each of these zones (6, 7), and the inclusion of a final treating zone wherein solid treating agents (such as desulphurizing agents) are added to the molten steel following its separation from the slag (8).

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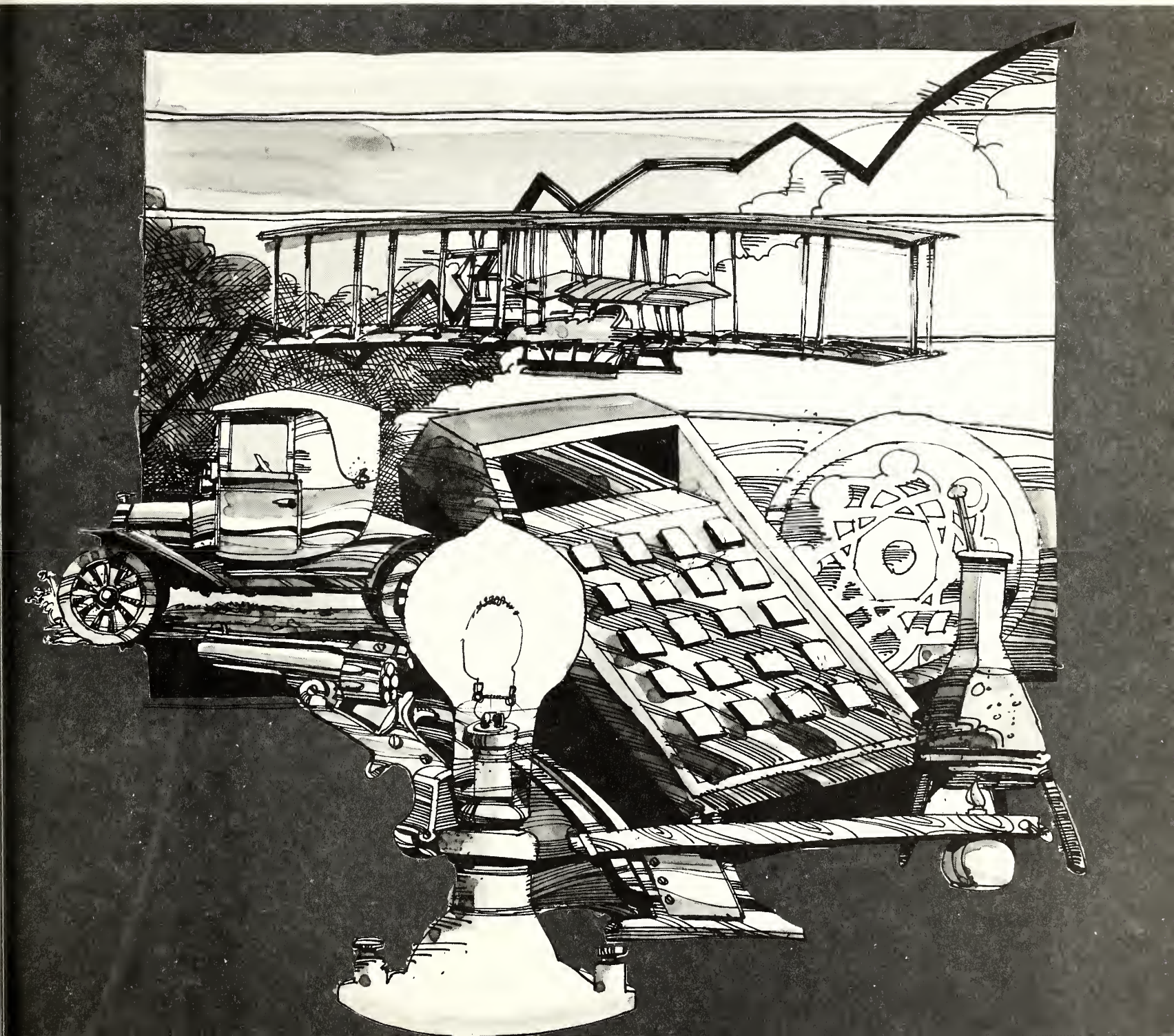
TECHNOLOGY ASSESSMENT & FORECAST

APPROPRIATE TECHNOLOGY

IV



SECTION IV - APPROPRIATE TECHNOLOGY

Experiment A :	Patent Technology Transfer to Small Businesses	148
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- - INTRODUCTION - -

In the year 1790, the first U.S. patent grant was awarded to Samuel Hopkins of Vermont for his invention of an improvement in the making of potash to be used in the manufacture of soap. The business or industry affected by this patent was certainly "small," as was the country, by today's standards, "underdeveloped." The technological information which Hopkins conveyed to this developing country and its infant manufacturing industry was new - - the "latest," so to speak - - but, more importantly, it also was suitable to the technical sophistication and economic resources of the industry, and to the developmental stage of the country as a whole. In a word, the technology was "appropriate."

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The concept presented in the preceding context cuts across a number of diverse opinions as to what really constitutes "appropriate technology" for infusion into developing industries or nations. Some would hold as "appropriate" only the "latest" in technical developments - - a position which would have the recipient of technology transfer "standing on the shoulders of giants," totally dependent upon services and expertise of highly developed suppliers. Others, at the opposite end of the spectrum, would have the small-scale recipients seek an "independent foothold" on technical basics - - obviously less-sophisticated technology, but one clearly suited to their resource endowments.

Regardless of how it is defined, the search for appropriate technology -- the "oldest" or the "latest" -- as well as its successful application when found, are not easy tasks. This is especially true for the disadvantaged prospective recipients with lesser economic and structural status.

In this Section, OTAF focuses upon experimental techniques for assisting the disadvantaged in the process of locating, transferring, and implementing technological information (whether it be basic or high-technology) suitable for filling a particular need or solving a problem encountered in industrial development.

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- - BACKGROUND - -

Commonality of Need

Today, small business and developing countries, diverse entities though they may be, share a distinct commonality in their pressing requirements for technology "appropriate" to their own special needs. It is particularly true of the lesser developed countries and, to a large extent, of small businesses, that they do not necessarily need (nor can they always use) the "latest" technology in solving their industrial problems. Besides, whether they would seek the newest, most sophisticated technical solutions, or solutions which are older and often forgotten, they face a number of disadvantages. In the first place, small businesses and developing countries frequently lack sufficient knowledge about and ready access to a comprehensive technological information source. Beyond that, they are usually without the ability and resources to effectively identify, channel and translate known technology into a useful problem-solving form.

Thus, for small business and developing nations handicapped in this manner, the process of appropriate technology search and application is reduced to two main questions. Where is the appropriate technology? How can this technology be successfully transferred?

"Where?" - - A Potential Resource

The U.S. patent file, with over twenty-two million patent documents categorized and distributed among approximately 100,000 subdivisions of technology reflects nearly every significant advance in applied science and technology over the last 189 years. This collection -- without equal throughout the world -- features detailed*, step-by-step developments in all fields of technology. Indeed, the patent file represents a major information resource -- a technological "supermart," so to speak, where prospective customers may select those technological solutions most suited to their level of sophistication and resource limits.

Thus, the patent file presents a potential "where" for the appropriate technology search and application process. However, addressing the "how" has proven far more complex, especially given the general lack of knowledge about file content and structure by those outside the patent field.

Help for the Disadvantaged

Many recognize the growing need for new initiatives -- imaginative and innovative efforts (public or private) geared not only to familarize the disadvantaged with the patent file as a potential, problem-solving resource, but also to develop an operative infrastructure to help them identify

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*By law, each patent must contain a full and clear description of the invention.

from the patent file, technology uniquely suited to their individual needs. To this purpose, a number of current projects, domestic and international in scope, have been undertaken.

The Patent and Trademark Office views the encouragement of such efforts, in either the public or private sector, as totally consistent with its goal of maximizing patent file use for the greatest public benefit. Successful programs of this type would generally serve to "promote the progress of science and the useful arts,"* and, beyond that, could enhance domestic industrial health and might significantly expand U.S. industry export markets through increased industrialization in the developing countries.

Experimental Efforts

OTAF, therefore, has selected two patent technology transfer experiments for discussion in this Section. The brief description of these currently operative projects is presented to apprise prospective users of the existence of such efforts and, moreover, to encourage development of new programs along this line.

Similar in basics, the experiments differ significantly in the diverse nature of the potential benefactors. The first, discussed as EXPERIMENT A, discloses a domestic effort to serve small businesses. The second, EXPERIMENT B, is set in an international framework and was formulated to assist developing countries.

Both projects provide succinct illustrations of positive, operational plans designed to tap the technical resources within the U.S. patent file, creating informational channels through which appropriate, problem-solving technology may be transferred to disadvantaged users. Emphasis in the small business project is primarily on domestic infrastructure design involving a wide array of actors, for example, industry, university staff, and private and public sector agencies. Conversely, the developing country experiment, though obviously involving the same appropriate technology search and application concept, focuses mainly upon efforts undertaken to identify and translate appropriate (though perhaps "old") patented technology. This international experiment addresses, to an extent, network formulation (private research firms/national institutes/government agencies/etc.).

These two plans, with their diversified applications, yet common underlying precepts, are described in the following pages.

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* U.S. Constitution, Article I, Section 8 - - the basis for the U.S. Patent System.

EXPERIMENT A

PATENT TECHNOLOGY TRANSFER TO SMALL BUSINESSES

A Partnership

A number of participants join hands in this effort to help smaller industrial firms to cope with the growing number of technical problems being thrust upon them, for example, by increased health and environmental regulation, energy shortages, and consumer protection demands.* Among those involved in this experimental partnership are: University of Missouri - Rolla (UMR) Department of Engineering Management; UMR Business-Industry Extension Specialists; Small Business Administration (SBA); and the Office of Technology Assessment and Forecast (OTAF) within the U.S. Patent and Trademark Office.

Simply stated, the intention, here, is to enhance the utilization of patent information by small business and industry -- recognizing, as discussed above, the value of the patent file as a potential problem-solving technology resource.

Specific objectives stated for this experiment are:

- to demonstrate how patented technology transfer to small business and industry can occur;
- to determine how firms can use such technology for goal achievement;
- to examine problems involved in the transfer of technological information;
- to ascertain the degree of technical assistance required;
- to determine whether industry can effectively and economically use such information at a cost commensurate with the return.

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* This experiment is the result of a proposal by Dr. John M. Amos, Professor and Director of the Center for Applied Engineering Management, Dept. of Engineering Management, University of Missouri-Rolla. The text of his proposal served as a valuable resource for preparation of this Section.

Program Operation

As schematically illustrated in Fig. 4-1, this experiment is being carried out in a series of phases.

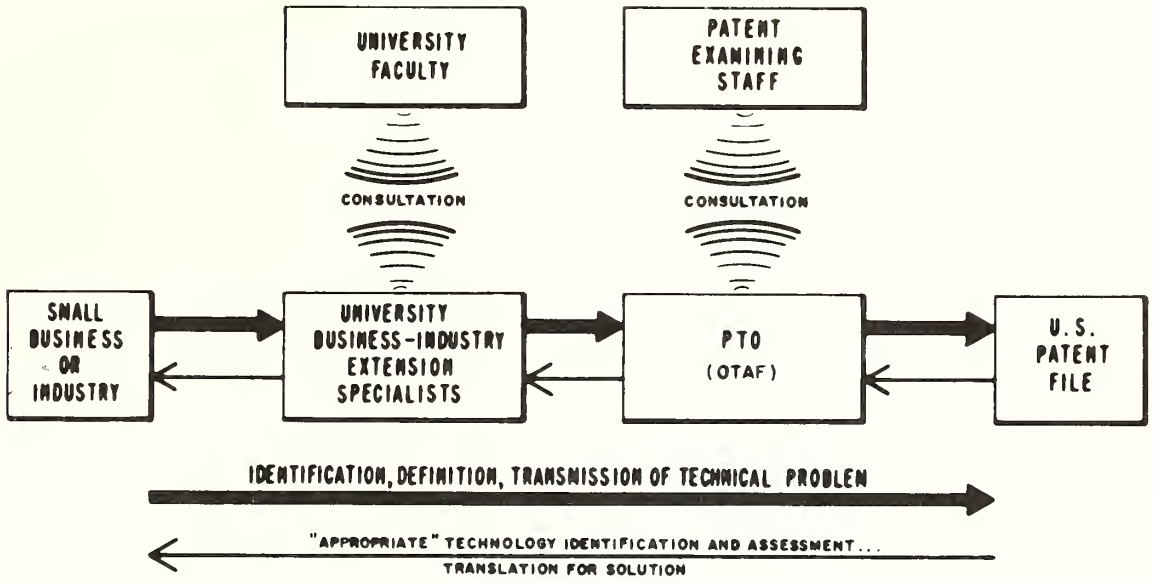

FIG.4-1: **PATENT TECHNOLOGY TRANSFER**
A COOPERATIVE EXPERIMENT

Phase I

A particular technical problem within a small business or industry is identified through the assistance of a University Business-Industry Specialist who, in turn, refers the problem to the University. (Alternatively, such problem may be referred by a Small Business Administration field office or by University Extension Specialists in other fields -- agriculture, community development, etc.) Complete definition of problem parameters may necessitate extensive consultation with University faculty and other campus experts -- likely involving utilization of research/testing experts and equipment, and facilities of specialized study units. Additionally, personal meetings between campus faculty members, the Extension Specialist, and a representative of the business firm may be required. The thrust of this initial interface effort is to clearly identify the needs of the small business and to pinpoint the technologies pertinent to those needs.

Phase II

In the next step of this experimental program the Business-Industry Specialist contacts OTAF for an assessment of the pertinent technology from the U.S. patent file. In this context, an "assessment" normally involves a special report* prepared by OTAF (on a cost-reimbursable basis),

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* Special Reports from OTAF may take a variety of forms as explained in Appendix C.

drawing upon the file of patent literature for appropriate technology which is considered specific to the small business needs. In preparing this report, OTAF may call upon the extensive expertise of the patent examining corps.

OTAF services and products, in this regard, are tailored as much as possible to meet requirements on a case-by-case basis, utilizing all U. S. Patent and Trademark Office information resources to the fullest extent feasible within available resource limitations.

Phase III

The OTAF report on the pertinent technology (including patent copies where appropriate) is transmitted by the Business-Industry Specialist to the University for in-depth analysis and, ultimately, formulation of problem-solving options which are then explored with the small business through a consultation process as in Phase I.

Phase IV

Once the appropriate technical information is translated and implemented, the Business-Industry Specialist will engage in "follow-up" visits to insure that progress is being made as a result of the previous counseling.

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The experiment just described is relatively new; consequently, measurable results are not available for evaluation. This effort has drawn interest, however, and OTAF anticipates the generation of similar experiments with other universities.

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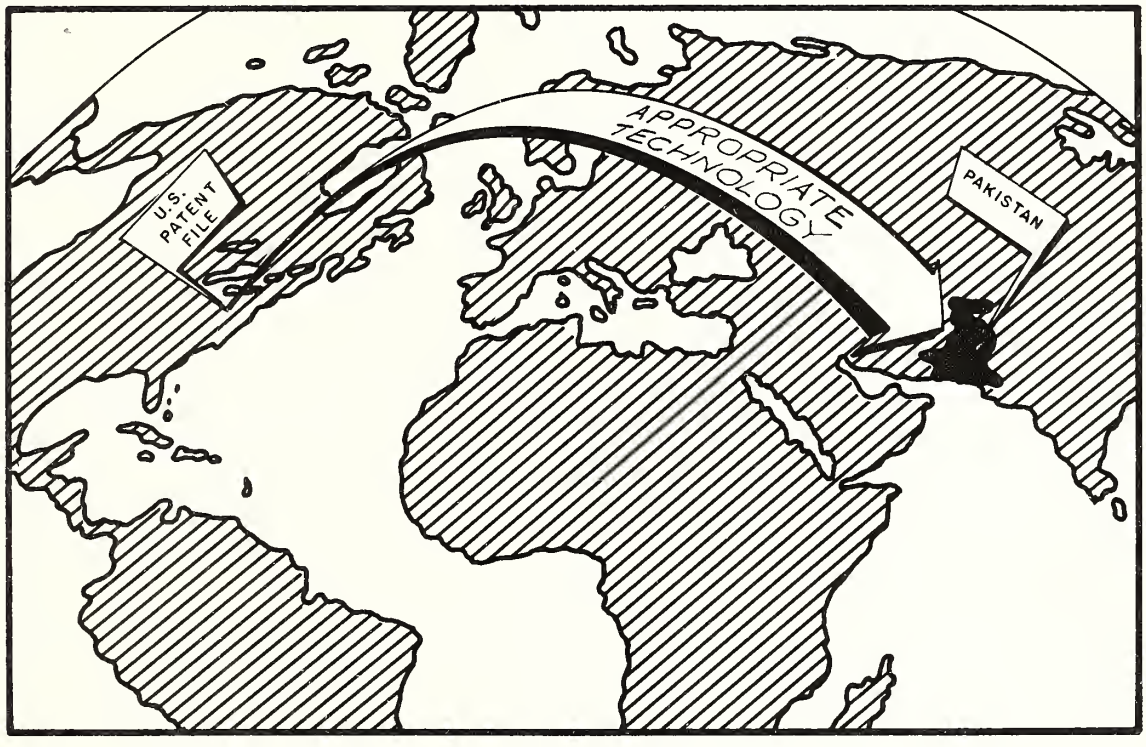
EXPERIMENT B

PATENT TECHNOLOGY TRANSFER TO DEVELOPING COUNTRIES

The University of Denver Research Institute has undertaken a study (within its Office of International Programs) specifically aimed at identifying appropriate technology within the U.S. patent file and effectively transferring such information to a developing country -- in this instance, Pakistan -- for application in solving a particular technological problem.



A paper authored by Theodore W. Schlie*, first published in Brazil in August of 1977, fully describes the operation of this experimental effort. With Mr. Schlie's consent, the text of that paper is fully reproduced in the following pages.

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* Mr. Schlie, formerly with the Office of International Programs, University of Denver Research Institute, currently serves with the Department of Commerce, Office of the Assistant Secretary for Science and Technology.

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THE UTILIZATION OF PATENT INFORMATION IN DEVELOPING COUNTRIES: AN UNFINISHED CASE STUDY.

The Office of International Programs of the University of Denver Research Institute (DRI) is carrying out several projects in the area of information related to technological development in developing countres. These projects are part of an overall program to increase the industrial scientific and technological infrastructure in developing countries by assisting existing industrial research institutes (or similar organizations) in those countries in becoming more useful and relevant to their intended clientele (i.e., local industry, particularly small-scale industry) and thus to their country. In attempting to achieve this objective, DRI has followed the strategy of developing linkages with selected industrial research institutes and forming a network of these institutes with DRI as a central node. In addition to informal linkages which DRI has established with industrial research institutes in some twenty-two developing countries, more formal and extensive working relationships have been developed with the Pakistan Council for Scientific and Industrial Research (PCSIR); the Instituto de Investigaciones Tecnologicas (IIT) in Bogota, Colombia; the Korean Institute of Science and Technology (KIST); the Federal Institute of Industrial Research (FIIR) in Nigeria; the Instituto de Pesquisas Tecnologicas (IPT) in Brazil; the Applied Scientific Research Corporation of Thailand (ASRCT); the Instituto Centroamericano de Investigacion y Tecnologia Industrial (ICAITI) in Guatemala, etc. These activities are, at present, sponsored principally by the Office of Science and Technology of USAID. Related information projects have been supported by the Division of Science Information of the National Science Foundation, the Office of Science and Technology of the United Nations, the International Center for Industrial Studies of the United Nations Industrial Development Organization, the Regional Office for Central American Programs of USAID, and by some developing countries themselves.

DRI regards itself as a research and experimental development organization for designing, field testing, and developing innovative approaches to the technological development of LDCs. Rather than attempting to compete with or improve on the many well developed scientific and technical information (STI) systems/services that already exist, DRI is focusing its limited efforts on what it perceives to be gaps in the provision of information to developing countries. In additon, DRI is planning its information activities in such a way as to build on the program's other technical assistance and technical extension efforts. In this paper, an attempt to utilize information contained in the U.S. patent files by the Pakistan Council for Scientific and Industrial Research (PCSIR) is described. This undertaking by DRI was supported by the Office of Science and Technology of the U.S. Agency for International Development.

From time to time, many people have suggested that there must be a great deal of potentially useful information contained in the U.S. patent files--information that would be particularly useful in developing countries. Included in these massive files, according to this viewpoint, should be

technological designs, drawings, blueprints, models, etc.--i.e., information--that would be of much use to design engineers and others, even if that information has been ignored or is outdated in the developed countries.

Except for those patents still in force, this information is essentially "free"--i.e., the patent documents are open and available to the public, but there are time and money costs in searching for the right patent (s) and for photocopying. Indeed, the purpose of the patent system is to promote the public disclosure of technical information by offering a reward of protection from competition for a limited period of time.

Most discussions on the use of patent information in developing countries have centered around identifying patents currently in force and the negotiation of fair licensing agreements. The approach in this experiment, however, was to attempt to utilize the free information contained in the patent files from numerous patents to improve the general level of design knowledge with respect to a specific item of equipment. This latter approach is obviously related to the concept of appropriate technology which recently has been receiving much attention. Technical information contained in older U.S. patents may, in fact, better reflect the capital-labor factor pricing, energy-scarcity, and scale of production conditions present in many developing countries today than does modern technology.

To the extent of our knowledge, patent information from any developed country has not been systematically exploited in this way for the benefit of the developing countries. The U.S. has supplied assistance to some of the more advance developing countries in modernizing their own patent systems and in evaluating licensing agreements, and agreements for the exchange of patents have been negotiated. Some years ago, there was also an attempt made to identify relevant U.S. Govermental patents and offer them to Latin American countries for exploitation, but nothing much ever came of this. Thus, although the idea of utilizing patent information keeps reappearing and has great appeal, its potential remains largely unfulfilled.

At least part of the reason for this unfulfilled potential lies in the staggering amount of documentary information contained in the U.S. patent files. Patent searching has become a profitable profession in its own right with specialized law firms dealing principally in this area. The inability to find the patents that would be useful for a given purpose among this huge volumn of material is one of the major barriers preventing developing country utilization of this information source.

With this background in mind, DRI initiated an experiment in the use of patent information with PCSIR in late 1975. After many discussions with PCSIR, a particular item of equipment was identified that was widely used in Pakistan--and, indeed, in most developing countries--tray or cabinet dryers used in small-scale food processing and chemical industries. Entrepreneurs in Pakistan have had numerous technical problems with existing dryers--uneven drying and caking, heat loss and inefficiency,

etc. Moreover, these dryers have to be imported from abroad into Pakistan; yet the technology and design engineering does not appear to be that difficult. Therefore, PCSIR was interested in the possibility of developing or adapting their own dryer designs which could be fabricated locally.

The objective that therefore evolved for this experiment was to see if useful design information on dryers could be provided to Pakistan from the U.S. patent files. Pakistan does not necessarily need the most modern and technically sophisticated dryers; information on older but still reliable and cost-effective dryer designs that can be adapted or redesigned to be manufactured locally is what was desired. From the beginning, it was not expected that a single patent would be found which would satisfy all of PCSIR's information needs, but rather that relevant technical features from many patents might be incorporated by PCSIR into an institutional reservoir of design know-how from which they could develop their own dryer designs.

Accordingly, the following steps were taken by DRI. A visit was made to the U.S. patent files in Arlington, Virginia, by the principal investigator for this project and author of this paper to become familiar with the patent files and search process, and to investigate the feasibility of carrying out such an experiment. After discussions with patent officials about the objectives and nature of this experiment and going through the patent classification system and the actual files, it was concluded that:

- There was official interest in the experiment. It appeared that nothing similar had been attempted before, and that the outcome would be regarded with some interest.

- There were numerous patents in the files on cabinet or tray dryers. It appeared from scanning them with an untrained eye that there might be much information that would be applicable in developing countries.

- The use of patent classification and indexing system and the manual identification of specific patents is a professional task. Amateurs can do it, but it is an inefficient use of manpower. Moreover, if the experiment was successful and more patent searches were required as a result, a routinized, professional search would appear to be desirable.

Therefore, the second step taken was to identify a professional patent search law firm that would do the kind of job required. After some discussions with several firms, one was identified which not only understood the objectives and nature of this experiment but also--it was felt--had some empathy for what we were trying to accomplish.

Subsequently, a contract was negotiated with this firm to do a professional search for tray/cabinet dryers. The search instructions emphasized the importance of designs, blueprints, drawings or other information in the patents which would indicate how the dryer might actually be constructed. Both obviously old or obsolete and very new or sophisticated information was to be avoided.

This search resulted in 92 patents being identified, ranging in dates from 1868 to 1968. Copies of these patents were sent to Denver where evaluative comments were made and attached to selected patents by DRI technical personnel. The total cost of this search was US$ $421--$375 for the actual search and $46 for photocopying charges.

These patents were forwarded to Paksitan in the summer of 1976 for evaluation and assessment by PCSIR scientists and engineers. Initial results of this experiment have just recently been fed back. During the period of time when the events described above were taking place, PCSIR's interests in drying had become more focused on fruit dehydration. Of the 68 patents which related to this interest, 13 were selected by them "as deserving further attention." The selection was made according to the following design criteria:

- Ease of fabrication;
- Amount of information contained on ventilation and convection currents, leading to drying efficiency; and
- Amount of information contained on heating efficiency and avoiding heat losses.

The examination of the total set of patents by PCSIR personnel is continuing, but in the meantime they are considering the developing and publication of a monograph which would synthesize the design information on dryers contained in the 13 selected patents.

Table 1, below, lists the patents which were selected by PCSIR for further attention. As can be quickly observed from this list, most of the patents

Table 1 - Patents Selected by PCSIR

Date of Patent	Patent No.	Title of Patent	Inventor
Oct. 24, 1871	120,242	Improvement in Driers	S. L. Cheyney
Aug. 7, 1877	193,947	Driers for Fruit and Other Articles	G. Harris
June 15, 1880	228,787	Fruit-Drier	G. Sikes
Sept. 7, 1880	232,033	Oven for Drying Fruit	G. W. Holmes
Dec. 20, 1881	251,213	Fruit Drier	C. J. Geiger
Oct. 17, 1882	266,148	Evaporator	J. C. Henderson
Oct. 30, 1883	287,542	Fruit Drier	J. H. Hunter
June 24, 1890	430,762	Drier for Fruits and Other Materials	H. H. Taylor
Nov. 7, 1893	508,113	Fruit Drier	J. H. Monteith
Feb. 20, 1917	1,217,051	Drier	W. F. Page
May 21, 1918	1,266,915	Desicator	J. W. Brooks
Aug. 31, 1920	1,351,118	Apparatus for Dehydrating Food Products	F. L. Nichols
Aug. 31, 1925	1,535,465	Grain Sprouter	W. H. Hackman

selected were from the late 1800's, with the remaining few from 1917-1925. This in itself supports the contention that there may be much appropriate technical information for developing countries contained in older U.S. patents--information that is not necessarily obsolete and which has not been exploited.

These patents do not describe totally new inventions or technological breakthroughs in the state-of-the-art of dryers. Rather, they concern improvements in dryers, incremental innovations which are intended to marginally improve the drying process. The technical details emphasized in the patents stongly reflect the selection criteria which PCSIR used--ventilation/convection currents and heating efficiency.

As requested in the patent search agreement, the 13 patents do have technical drawings which show some design detail--an average of 3.6 figures included in each.

Most of the patents selected reflect PCSIR's focus on fruit dryers. This was not one of the selection criteria, however, and a few of the patents concern the drying of other products such as wood, clothes, and even human excrement (which was intended for commerical fertilizer). One of the patents did not even concern drying al all, but a device in which a current of warm moist air would pass over grain in order to make it sprout. This indicates that PCSIR truly understands the nature of this experiment in attempting to use patents as a source of technical information--not to identify a single patent that is desired for a specific purpose.

This case study is not yet completed, of course. The ultimate use of the patent information is the most important issue and this remains to be seen. DRI will continue to work with PCSIR, in following up on this experiment and attempting to learn if and how patent information might be used in developing countries. We do feel that the results to date are positive and that the possibilities of utilizing patent information as described above are promising and worthy of replication and further development.

In summary, the following features of this experiment are perceived to be important to its success to date and should be taken into account in any attempt to replicate it:

- There was a competent scientific and technical counterpart organization in Pakistan--PCSIR--to utilize the information;
- There was both interest and commitment on the part of PCSIR with respect to the experimental--"let's try it"--nature of the information;
- A specific item of equipment was selected which was in widespread use in Pakistan and for which a large number of patents existed in the U.S. files;
- The objective was to provide general design information that would raise PCSIR's ability to design or adapt their own equipment--not to find a single patent that would serve as a technical model and be the answer to all of the problems that existed;
- A professional law firm was identified to do the patent search which understood the objectives and nature of the experiment; and
- PCSIR was able to define and focus its interests, and to develop criteria based on them, which enabled their scientists to select those patents which were likely to be of most use.

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NOTE:
As presently advised, the Denver Research Institute study described above remains unfinished. OTAF will continue to monitor the progress of this experiment as well as other programs in this field.

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-- IN CONCLUSION--

The experimental efforts just described demonstrate plausible solutions to both the "where" and the "how" of the appropriate technology search and application process -- especially for struggling or disadvantaged small businesses and developing countries. These projects exemplify the increased attention being focused upon the U.S. patent file as an incomparable source of technological information (from the most basic to the most sophisticated) and the promising attempts to create workable infrastructures to successfully transfer that information.

Domestically, there are a number of efforts in both the public and private sector to familiarize small industries with the patent system and the file content --to help with their developmental problems as well as improve their innovative potential. Internationally, as developing nations look beyond their boundaries for the technology they need, interest in the U.S. patent file as a technological information source has sharply increased, as evidenced by discussion in several recent workshops, symposia, and conferences (e.g., in Munich, Havana, Mexico City, and Cairo).

It is hoped that efforts of the type discussed in this section will continue and will result in enhancement of the flow of technological information. Successful use of the patent file in this manner may prove to be, after all, an effective form of appropriate technology transfer.

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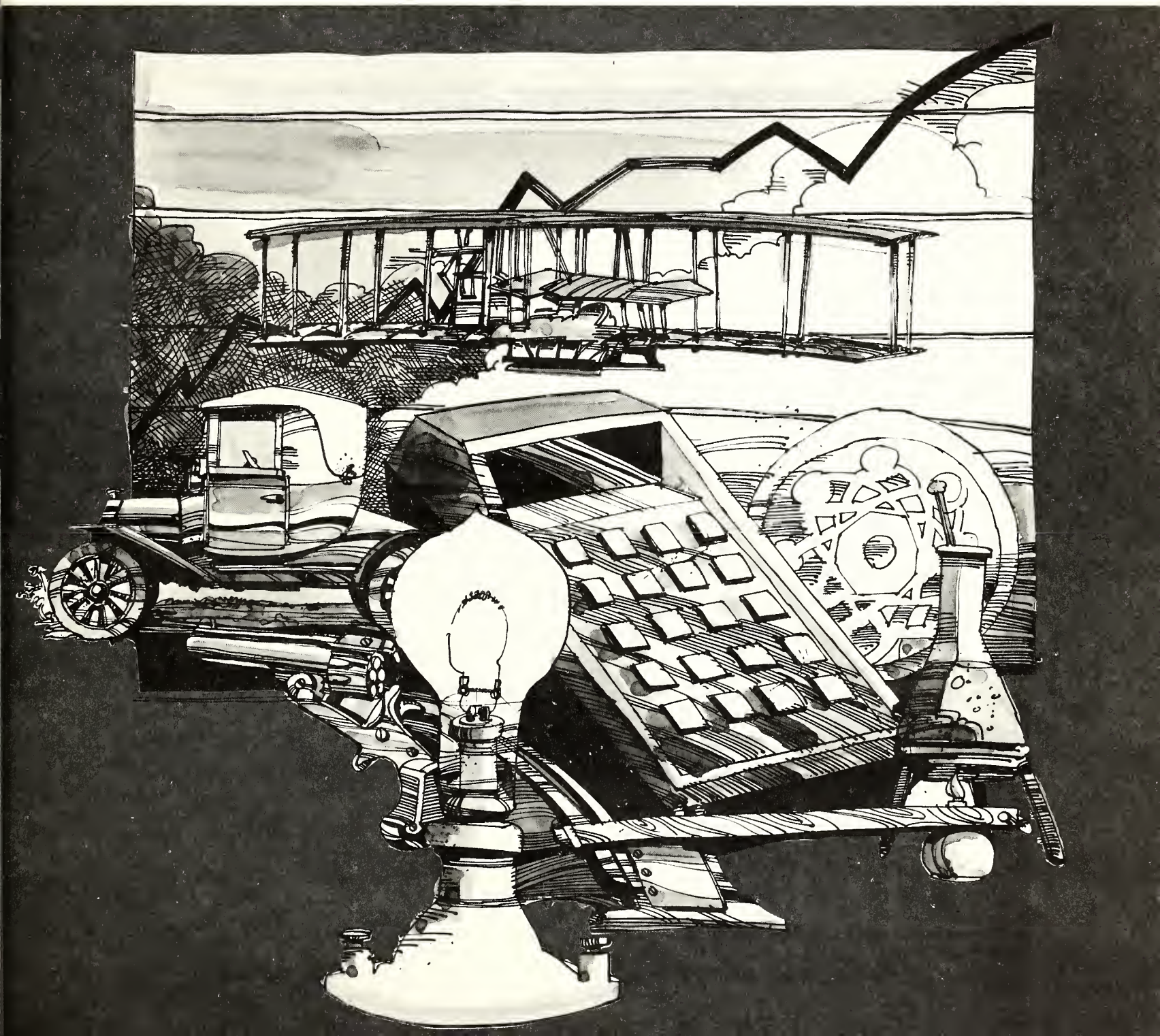
TECHNOLOGY ASSESSMENT & FORECAST

APPENDICES



APPENDIX - A

This Appendix contains the data illustrated in Section-II, Figure 2-8: Given is the 1969-1977 U. S. Patenting of the 113 most patent active corporations both by patent grant date and by patented application filing date.

Included in the data presented for each corporation, is the U. S. Patenting (both U. S. origin and foreign origin) of the parent organization and all subsidiaries of the parent organization.

113 MOST PATENT ACTIVE DOMESTIC CORPORATIONS 1969-1977

	PRE 64	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	TOTAL
GENERAL ELECTRIC COMPANY																
Patents Granted							1195	1079	1201	956	1080	1022	854	824	845	9056
Patented Applications	56	62	218	601	824	916	900	862	902	848	890	822	780	363	11	9056
AMERICAN TELEPHONE AND TELEGRAPH COMPANY																
Patents Granted							782	782	881	798	678	543	464	456	447	5831
Patented Applications	61	46	228	417	557	652	619	623	609	521	363	442	428	253	11	5831
INTERNATIONAL BUSINESS MACHINES CORPORATION																
Patents Granted							589	632	788	628	632	568	489	480	502	5308
Patented Applications	26	81	223	304	405	508	608	526	511	533	464	428	474	212	5	5308
E. I. DU PONT DE NEMOURS AND COMPANY																
Patents Granted							667	612	608	713	559	547	556	491	451	5204
Patented Applications	54	58	168	333	531	526	528	492	526	480	489	422	403	189	5	5204
WESTINGHOUSE ELECTRIC CORPORATION																
Patents Granted							553	539	685	592	575	627	507	462	498	5038
Patented Applications	21	28	119	257	389	524	536	498	518	499	578	473	411	184	3	5038
GENERAL MOTORS CORPORATION																
Patents Granted							482	390	681	605	663	584	495	402	290	4592
Patented Applications	9	19	72	156	278	413	475	602	550	555	507	440	307	200	9	4592
EASTMAN KODAK COMPANY																
Patents Granted							417	510	636	628	525	383	284	213	249	3845
Patented Applications	23	29	122	202	445	478	401	495	458	386	263	228	194	117	4	3845
DOW CHEMICAL COMPANY, THE																
Patents Granted							497	418	423	472	406	401	367	293	296	3573
Patented Applications	31	54	121	247	349	454	369	350	327	323	335	272	206	129	6	3573
RCA CORPORATION																
Patents Granted							308	327	453	403	331	341	398	423	429	3413
Patented Applications	18	24	94	167	245	295	300	330	308	294	342	386	394	213	3	3413
XEROX CORPORATION																
Patents Granted							216	217	304	367	287	357	465	548	492	3253
Patented Applications	4	25	81	182	150	168	307	264	266	276	455	462	434	175	4	3253
PHILLIPS PETROLEUM COMPANY																
Patents Granted							438	400	422	428	324	354	313	299	271	3249
Patented Applications	27	52	81	260	335	308	387	332	321	273	289	224	250	109	1	3249
MONSANTO COMPANY																
Patents Granted							526	369	469	433	299	285	244	271	200	3096
Patented Applications	31	43	142	281	324	404	362	327	257	225	215	241	186	58		3096
INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION																
Patents Granted							303	360	382	361	307	315	303	294	250	2875
Patented Applications	19	12	100	216	252	248	274	314	222	284	263	304	233	129	5	2875
GTE SYLVANIA INCORPORATED																
Patents Granted							197	219	298	262	296	319	283	244	236	2354
Patented Applications	8	11	42	97	156	202	187	227	222	289	301	254	224	131	3	2354
ROCKWELL INTERNATIONAL CORPORATION																
Patents Granted							297	285	357	275	271	200	191	178	176	2230
Patented Applications	34	31	71	151	239	233	255	261	203	175	174	138	165	97	3	2230

113 MOST PATENT ACTIVE DOMESTIC CORPORATIONS 1969-1977 (Continued)

	PRE 64	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	TOTAL
UNION CARBIDE CORPORATION																
Patents Granted							309	261	237	265	228	208	230	221	226	2185
Patented Applications	32	47	77	134	172	250	219	216	204	207	163	199	167	95	3	2185
SHELL OIL COMPANY																
Patents Granted							321	287	271	301	246	166	153	167	186	2098
Patented Applications	18	29	54	128	219	285	264	217	225	131	135	130	136	119	8	2098
CATERPILLAR TRACTOR CO.																
Patents Granted							178	116	181	104	190	242	291	363	368	2033
Patented Applications	2	2	4	32	125	157	141	129	165	191	210	275	400	195	5	2033
HONEYWELL INC.																
Patents Granted							225	219	265	241	277	245	188	186	183	2029
Patented Applications	5	16	61	108	174	203	165	213	227	205	220	175	182	73	2	2029
TEXAS INSTRUMENTS, INCORPORATED																
Patents Granted							231	250	290	205	175	211	210	251	161	1984
Patented Applications	13	20	59	174	191	202	215	176	163	121	234	235	138	43		1984
UNIVERSAL OIL PRODUCTS COMPANY																
Patents Granted							242	213	202	256	209	199	205	219	213	1958
Patented Applications	2	4	33	99	166	221	213	198	183	166	166	203	192	108	4	1958
FORD MOTOR COMPANY																
Patents Granted							276	211	270	188	216	239	220	174	117	1911
Patented Applications	10	9	33	85	193	215	195	213	192	175	201	212	121	55	2	1911
BENDIX CORPORATION																
Patents Granted							226	225	306	253	289	211	162	125	87	1884
Patented Applications	12	12	47	76	164	236	231	247	237	188	161	130	108	35		1884
TEXACO INC.																
Patents Granted							110	112	185	207	238	272	260	222	202	1808
Patented Applications	12	8	18	42	105	144	163	190	226	200	215	260	150	75		1808
MINNESOTA MINING AND MANUFACTURING COMPANY																
Patents Granted							167	187	201	232	213	199	238	194	170	1801
Patented Applications	25	20	54	94	118	177	190	172	178	181	203	176	150	62	1	1801
UNITED TECHNOLOGIES CORPORATION																
Patents Granted							227	211	228	174	231	158	177	214	175	1795
Patented Applications	15	19	43	114	160	194	180	151	163	149	141	175	209	82		1795
SPERRY RAND CORPORATION																
Patents Granted							231	218	236	244	196	177	159	154	148	1763
Patented Applications	30	35	75	85	153	141	175	240	183	144	133	150	140	78	1	1763
MOTOROLA INC.																
Patents Granted							159	178	208	208	238	158	166	190	213	1718
Patented Applications	1	4	31	96	137	107	149	210	211	147	165	175	200	83	2	1718
MOBIL OIL CORPORATION																
Patents Granted							199	193	134	194	150	174	169	173	194	1580
Patented Applications	15	14	39	103	132	153	168	145	133	114	150	171	161	79	3	1580
FMC CORPORATION																
Patents Granted							234	210	221	221	176	173	127	93	112	1567
Patented Applications	5	12	47	118	172	187	186	188	158	148	124	87	87	48		1567

113 MOST PATENT ACTIVE DOMESTIC CORPORATIONS 1969-1977 (Continued)

	PRE 64	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	TOTAL
ALLIED CHEMICAL CORPORATION																
Patents Granted							192	150	181	224	184	150	169	139	124	1513
Patented Applications	16	20	67	91	124	167	202	120	164	135	123	126	104	49	5	1513
OWENS-ILLINOIS INC.																
Patents Granted							191	135	145	138	180	207	139	157	137	1429
Patented Applications	5	22	67	120	99	76	121	142	194	145	165	103	108	61	1	1429
PPG INDUSTRIES INC.																
Patents Granted							140	115	121	167	133	161	171	180	196	1384
Patented Applications	3	12	43	67	81	111	134	115	123	144	150	142	154	100	5	1384
POLAROID CORPORATION																
Patents Granted							126	106	169	178	182	209	141	121	119	1351
Patented Applications	7	8	29	71	99	118	123	138	153	179	164	135	80	47		1351
UPJOHN COMPANY																
Patents Granted							101	106	108	135	123	144	171	203	200	1291
Patented Applications	13	12	26	60	83	90	105	104	114	97	130	193	157	105	2	1291
SINGER COMPANY																
Patents Granted							147	123	180	151	160	183	135	105	106	1290
Patented Applications	13	6	13	40	128	108	138	144	154	125	136	101	119	65		1290
MERCK + CO., INC.																
Patents Granted							141	131	122	171	138	118	141	155	147	1264
Patented Applications	12	11	41	72	102	123	146	138	112	94	96	119	127	69	2	1264
TRW INC.																
Patents Granted							128	165	193	156	146	146	107	104	88	1233
Patented Applications	10	10	17	63	151	135	127	147	132	123	101	97	83	37		1233
CORNING GLASS WORKS																
Patents Granted							127	135	159	120	121	142	142	136	119	1201
Patented Applications	2	10	43	57	119	128	100	97	105	110	121	137	106	66		1201
AMP INCORPORATED																
Patents Granted							122	126	156	132	127	120	147	115	107	1152
Patented Applications	4	11	13	47	102	119	104	128	95	89	146	126	90	72	6	1152
W. R. GRACE + CO.																
Patents Granted							138	136	157	168	115	119	116	105	67	1121
Patented Applications	7	4	32	62	124	140	124	114	124	83	105	88	79	34	1	1121
GOODYEAR TIRE + RUBBER COMPANY																
Patents Granted							99	104	132	137	103	133	144	132	122	1106
Patented Applications	3	10	9	40	81	117	111	137	104	109	95	133	101	55	1	1106
AMERICAN HOME PRODUCTS CORPORATION																
Patents Granted							138	162	116	121	94	111	160	107	90	1099
Patented Applications	2		14	69	132	151	112	76	93	108	102	112	90	37	1	1099
BURROUGHS CORPORATION																
Patents Granted							124	138	170	164	104	90	89	106	106	1091
Patented Applications	9	14	40	54	119	81	122	142	94	82	90	80	120	43	1	1091
STAUFFER CHEMICAL COMPANY																
Patents Granted							92	75	100	134	133	125	136	158	121	1074
Patented Applications	4	11	23	41	64	108	82	136	115	89	107	127	114	51	2	1074

113 MOST PATENT ACTIVE DOMESTIC CORPORATIONS 1969-1977 (Continued)

	PRE 64	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	TOTAL
WARNER-LAMBERT COMPANY																
Patents Granted							89	86	111	128	113	130	154	121	126	1057
Patented Applications	10	18	28	43	61	61	113	89	113	107	111	134	118	51		1057
COLGATE-PALMOLIVE COMPANY																
Patents Granted							70	86	85	104	126	135	149	167	125	1047
Patented Applications	3	7	20	61	61	50	83	94	124	134	118	136	110	45	1	1047
OLIN CORPORATION																
Patents Granted							108	110	118	128	123	99	113	122	109	1030
Patented Applications	16	8	27	37	84	134	93	89	92	93	91	107	92	64	3	1030
GULF OIL CORPORATION																
Patents Granted							104	136	140	166	129	104	79	72	84	1014
Patented Applications	3	12	18	73	88	121	148	117	112	87	73	60	63	39		1014
UNITED STATES STEEL CORPORATION																
Patents Granted							113	125	146	131	147	93	92	86	78	1011
Patented Applications	1	3	13	41	98	109	121	119	129	113	88	74	66	35	1	1011
CELANESE CORPORATION																
Patents Granted							119	115	93	137	125	119	94	80	82	964
Patented Applications	1	28	29	70	88	79	102	111	128	82	78	80	56	31	1	964
PROCTER + GAMBLE COMPANY																
Patents Granted							71	100	149	120	98	101	95	129	95	958
Patented Applications	5	1	19	63	76	105	101	97	96	84	89	88	101	33		958
BORG-WARNER CORPORATION																
Patents Granted							123	107	122	101	89	100	82	84	78	886
Patented Applications	7	2	15	28	98	105	114	84	90	85	70	82	72	33	1	886
OCCIDENTAL PETROLEUM CORPORATION																
Patents Granted							116	119	76	115	68	68	101	102	105	870
Patented Applications	14	16	52	57	89	72	79	77	72	50	79	80	100	32	1	870
ETHYL CORPORATION																
Patents Granted							105	99	87	131	83	122	114	73	46	860
Patented Applications	13	11	22	59	108	88	104	85	83	71	93	63	48	11	1	860
E. R. SQUIBB + SONS, INC.																
Patents Granted							68	60	46	56	100	118	145	147	115	855
Patented Applications	3	5	11	27	51	66	44	81	76	100	89	109	116	73	4	855
ATLANTIC RICHFIELD COMPANY																
Patents Granted							65	65	119	128	78	108	104	93	81	841
Patented Applications	3	2	9	31	54	118	90	97	67	84	88	80	80	38		841
ALLIS-CHALMERS CORPORATION																
Patents Granted							109	106	108	85	92	116	68	69	70	823
Patented Applications	2	3	8	31	96	99	76	93	53	105	79	82	66	28	2	823
EATON CORPORATION																
Patents Granted							95	102	130	76	82	86	93	65	85	814
Patented Applications	1	2	2	27	107	96	101	67	84	60	83	81	60	43		814
ELI LILLY AND COMPANY																
Patents Granted							42	52	45	77	72	108	125	148	137	806
Patented Applications	5	2	15	15	29	46	69	60	75	85	96	124	107	77	1	806

113 MOST PATENT ACTIVE DOMESTIC CORPORATIONS 1969-1977 (Continued)

	PRE 64	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	TOTAL
AMERICAN STANDARD, INC.																
Patents Granted							102	114	130	100	81	75	56	57	67	782
Patented Applications	5	4	11	36	86	116	99	93	70	61	49	53	59	35	5	782
INTERNATIONAL HARVESTER COMPANY																
Patents Granted							157	90	98	93	65	77	69	71	49	769
Patented Applications	1	1	14	48	94	99	71	111	53	67	65	50	72	22	1	769
RAYTHEON CORPORATION																
Patents Granted							66	62	65	88	108	118	80	103	72	762
Patented Applications	15	6	10	25	45	49	62	85	86	94	96	82	75	32		762
HERCULES INCORPORATED																
Patents Granted							107	71	85	145	87	73	73	61	51	753
Patented Applications	17	6	15	53	71	71	105	95	68	69	66	43	53	21		753
NCR CORPORATION																
Patents Granted							72	99	108	12	99	86	45	50	76	747
Patented Applications	3	5	17	55	57	66	101	98	83	77	41	44	69	30	1	747
OWENS-CORNING FIBERGLAS CORPORATION																
Patents Granted							60	96	79	77	69	91	100	87	70	729
Patented Applications	4	4	13	50	60	70	69	62	77	73	67	91	65	23	1	729
COMBUSTION ENGINEERING INC.																
Patents Granted							102	67	72	72	71	96	80	85	83	728
Patented Applications	1	7	15	44	69	71	57	66	84	69	77	72	64	32		728
ROBERTSHAW CONTROLS COMPANY																
Patents Granted							78	91	96	90	71	95	57	83	62	723
Patented Applications	1	4	10	29	61	81	86	76	54	80	81	71	67	21	1	723
GENERAL DYNAMIC CORPORATION																
Patents Granted							115	112	112	69	72	63	56	64	51	714
Patented Applications	5	9	23	97	75	81	68	59	62	56	48	57	46	28		714
DRESSER INDUSTRIES, INC.																
Patents Granted							107	70	80	70	70	82	86	83	63	711
Patented Applications	3	3	14	46	64	86	60	47	72	52	75	76	76	35	2	711
UNIROYAL, INC.																
Patents Granted							69	80	65	92	67	96	87	93	51	700
Patented Applications	3	8	25	36	67	58	63	73	66	68	74	80	54	25		700
GAF CORPORATION																
Patents Granted							107	107	92	83	76	87	66	54	26	698
Patented Applications	7	11	35	74	96	66	61	80	71	84	39	44	23	7		698
CONTINENTAL OIL COMPANY																
Patents Granted							80	61	55	79	74	87	102	91	64	693
Patented Applications	2	8	19	30	39	69	62	61	72	65	81	82	67	33	3	693
B. F. GOODRICH COMPANY																
Patents Granted							72	81	72	94	72	60	85	72	77	685
Patented Applications	5	3	14	40	62	56	71	68	69	56	59	61	83	29	9	685
BELL + HOWELL COMPANY																
Patents Granted							72	69	106	81	77	85	59	61	73	683
Patented Applications	1	3	27	37	54	61	88	58	66	82	62	57	57	30		683

113 MOST PATENT ACTIVE DOMESTIC CORPORATIONS 1969-1977 (Continued)

	PRE 64	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	TOTAL
DEERE + COMPANY																
Patents Granted							76	65	82	64	87	83	61	80	69	667
Patented Applications		1	12	21	47	75	59	70	63	75	60	62	83	38	1	667
VARIAN ASSOCIATES, INC.																
Patents Granted							107	109	110	51	62	68	60	63	37	667
Patented Applications	8	4	14	59	107	72	79	56	48	46	56	65	34	19		667
SUN OIL COMPANY																
Patents Granted							84	102	96	108	69	50	53	70	29	661
Patented Applications	5	4	6	36	83	108	83	84	64	42	31	61	46	8		661
AMERICAN CAN COMPANY																
Patents Granted							74	41	77	76	79	72	67	63	90	639
Patented Applications	3	8	10	38	38	66	65	48	77	56	66	55	63	45	1	639
WHIRLPOOL CORPORATION																
Patents Granted							76	82	80	78	74	67	72	58	40	627
Patented Applications	7	8	16	29	53	65	63	67	72	46	69	78	44	9	1	627
ZENITH RADIO																
Patents Granted							48	74	86	71	84	52	65	77	58	615
Patented Applications	2	2	12	34	47	58	56	61	65	63	57	75	53	29	1	615
TEXTRON INC.																
Patents Granted							46	51	89	71	71	79	80	60	55	602
Patented Applications	3		8	18	37	57	70	64	66	75	66	52	62	24		602
MCDONNEL DOUGLAS CORPORATION																
Patents Granted							74	67	84	60	80	61	52	64	45	587
Patented Applications	7	12	21	42	51	60	56	57	69	52	47	56	40	17		587
PFIZER INC.																
Patents Granted							3	7	49	73	68	62	113	108	101	584
Patented Applications	1	1	2	2	10	26	52	52	63	61	66	109	80	56	3	584
ROHM AND HAAS COMPANY																
Patents Granted							48	47	35	70	62	87	55	69	97	570
Patented Applications	24	4	15	29	35	27	56	59	64	58	61	49	71	18		570
BOEING COMPANY																
Patents Granted							49	52	73	35	45	59	81	88	83	565
Patented Applications	4	4	11	32	31	47	41	47	31	41	73	89	78	35	1	565
ILLINOIS TOOL WORKS INC.																
Patents Granted							48	57	59	50	36	80	107	69	56	562
Patented Applications			2	15	20	65	60	47	42	49	69	89	65	39		562
AVCO CORPORATION																
Patents Granted							54	74	90	62	89	72	56	31	26	554
Patented Applications	6	2	15	25	36	65	78	60	74	69	54	35	24	11		554
HEWLETT-PACKARD COMPANY																
Patents Granted							72	65	70	50	64	45	51	69	58	544
Patented Applications	1	5	15	36	37	68	42	47	47	58	44	54	69	20	1	544
U.S.M. CORPORATION																
Patents Granted							66	61	78	58	66	56	42	47	41	515
Patented Applications		3	7	20	51	58	58	64	51	58	39	38	39	28	1	515

113 MOST PATENT ACTIVE DOMESTIC CORPORATIONS 1969-1977

	PRE 64	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	TOTAL
UNION OIL COMPANY OF CALIFORNIA																
Patents Granted							48	67	45	92	68	54	45	28	67	514
Patented Applications	5	11	11	27	45	55	61	65	49	49	41	21	39	35		514
PENNWALT CORPORATION																
Patents Granted							81	67	61	53	53	55	40	56	38	504
Patented Applications	2	1	19	42	55	64	45	51	47	40	40	51	29	18		504
G. D. SEARLE + CO.																
Patents Granted							51	46	46	57	49	69	48	66	66	498
Patented Applications		2	6	24	38	57	44	38	49	47	56	50	49	37	1	498
GENERAL FOODS CORPORATION																
Patents Granted							38	27	46	62	58	64	64	62	56	477
Patented Applications	2	1	16	19	23	29	49	61	49	62	60	55	40	11		477
BUNKER RAMO CORPORATION																
Patents Granted							56	39	87	69	54	61	35	42	34	477
Patented Applications	1	8	14	34	35	32	67	58	62	43	41	37	33	12		477
BECKMAN INSTRUMENTS INC.																
Patents Granted							93	65	66	52	44	41	33	36	46	476
Patented Applications	1	16	28	55	41	49	41	49	29	45	41	32	25	23	1	476
CARRIER CORPORATION																
Patents Granted							53	38	101	54	61	62	36	31	33	469
Patented Applications	2	2	8	12	29	53	67	67	55	49	41	34	35	14	1	469
KOPPERS COMPANY INC.																
Patents Granted							58	87	63	37	44	55	39	51	35	469
Patented Applications	2		14	24	57	57	55	35	50	42	42	37	39	13	2	469
P. R. MALLORY + CO., INC.																
Patents Granted							72	51	41	63	61	59	36	44	39	466
Patented Applications			6	35	46	37	53	52	62	47	51	34	25	17	1	466
ALUMINUM COMPANY OF AMERICA																
Patents Granted							30	29	39	50	68	76	53	72	49	466
Patented Applications		2	1	18	22	23	41	41	71	63	50	43	62	28	1	466
STERLING DRUG INC.																
Patents Granted							47	47	44	57	44	43	59	63	59	463
Patented Applications	3	3	10	30	46	41	45	47	38	27	55	40	56	22		463
AMF INCORPORATED																
Patents Granted							63	94	84	36	40	39	45	33	27	461
Patented Applications	3	7	11	25	57	72	65	43	29	27	41	36	26	17	2	461
SCM CORPORATION																
Patents Granted							45	40	58	59	50	52	51	62	41	458
Patented Applications	1	6	10	28	30	41	57	42	45	33	51	53	42	19		458
PULLMAN, INCORPORATED																
Patents Granted							56	53	76	54	59	61	33	25	34	451
Patented Applications	2	5	7	24	49	54	56	47	46	53	33	22	37	16		451
NALCO CHEMICAL COMPANY																
Patents Granted							53	36	50	48	42	37	55	63	48	432
Patented Applications		5	18	25	27	32	43	32	42	39	35	55	53	25	1	432

113 MOST PATENT ACTIVE DOMESTIC CORPORATIONS 1969-1977

	PRE 64	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	TOTAL
ABBOTT LABORATORIES																
Patents Granted							37	20	33	57	46	70	60	52	57	432
Patented Applications	2	3	3	21	28	21	26	47	42	61	62	56	46	14		432
THIOKOL CORPORATION																
Patents Granted							105	62	49	47	53	28	29	35	20	428
Patented Applications	22	13	33	69	53	52	34	35	30	25	22	18	15	6	1	428
CITIES SERVICE COMPANY																
Patents Granted							13	29	74	73	100	54	34	21	25	423
Patented Applications		1	6	6	23	38	53	76	87	56	21	19	20	17		423
ADDRESSOGRAPH-MULTIGRAPH CORPORATION																
Patents Granted							37	33	63	53	58	37	54	43	45	423
Patented Applications	3	1	8	25	24	32	50	49	43	28	59	47	38	15	1	423
REYNOLDS METALS COMPANY																
Patents Granted							91	61	68	43	46	41	23	25	21	419
Patented Applications	2	5	10	50	58	59	45	39	43	33	23	20	21	11		419
KIMBERLY-CLARK CORPORATION																
Patents Granted							40	43	55	93	63	48	31	27	13	413
Patented Applications	1		10	24	31	27	70	78	57	37	29	22	19	6	2	413
BETHLEHEM STEEL CORPORATION																
Patents Granted							40	47	61	62	49	58	42	19	26	404
Patented Applications		1	5	16	36	54	50	58	33	50	38	35	15	13		404
FIRESTONE TIRE AND RUBBER COMPANY																
Patents Granted							29	38	43	43	46	44	58	61	30	392
Patented Applications	2	4	9	16	29	29	39	32	46	40	42	53	36	13	2	392

APPENDIX B

OBTAINING PREVIOUS OTAF PUBLICATIONS **

Copies of the previous OTAF publications listed below are available from:

National Technical Information Service (NTIS)
5285 Port Royal Rd.
Springfield, Virginia 22161
(703) 557-4690

When ordering from NTIS, please give the publication title and its "COM" or "PB" number.

1. Initial Publication, May 1973
COM 73-10767; Cost: Domestic - $6.50 Foreign - $13.00

   Describes OTAF program and gives sample reports on 24 wide ranging areas of technology in varying levels of detail.

2. Early Warning Report, December 1973
COM 74-10150; Cost: Domestic - $11.00 Foreign - $22.00

   Spotlights those technological areas experiencing a high level of overall activity or of foreign activity. Reviews patent activity in a number of energy areas, including nuclear; solar; geothermal; and tide, wind and wave energy.

3. Third Report, June 1974
COM 74-11383; Cost: Domestic - $9.00 Foreign - $18.00

   Presents an overview of the technological activity, across all technologies, of a group of selected foreign countries and a group of selected U.S. states. Extends energy area treatments to include oil shale and coal gasification technologies. Reviews additional high overall activity technological areas.

4. Fourth Report: A Review of Patent Ownership, January 1975
COM 75-10050; Cost: Domestic - $7.25 Foreign - $14.50

   Identifies the 73 corporations and government agencies which received 500 or more patents during the five year period 1969-1973, and reviews and compares their patent activity across the spectrum of technology. Also reviews in terms of patent ownership, the patent activity during the same period, in nuclear energy technology and oil shale and coal gasification technology.

** SPECIAL NOTE: NTIS AND GPO PRICES ARE SUBJECT TO CHANGE WITHOUT NOTICE.

5. Fifth Report, August 1975
COM 75-11142, Cost: Domestic - $8.00 Foreign - $16.00

Reviews 60 technological areas, not previously reported on, experiencing a high level of overall activity or of foreign activity. Presents patent activity data in categories corresponding to 36 Product Fields of the Standard Industrial Classification System.

6. Sixth Report, June 1976
PB 254188, Cost: Domestic - $9.00 Foreign - $18.00

Reviews 15 technologies with unusually high activity by foreign resident inventors, and 22 high overall activity technologies; updates the 1973 reports on patent activity in solar and other natural energy sources, and adds reports on the use of waste material and wind for energy generation. Presents comparisions of patenting to R&D expenditures and R&D manpower allocations in six selected industries. The report concludes with a review of six most often cited patents in 1975, 5 U.S. and 1 foreign patent.

7. Seventh Report, March 1977*
PB 265792, Cost: Domestic - $9.25 Foreign - $18.50

Reviews historical patenting and trademark registration trends, and includes the most extensive collection of historical U.S. patent data ever presented in a single publication. Makes first use in the series of data relating to patents granted by foreign nations for a study of invention sources. Makes first use in the series of pending patent application data for forecasting. Presents brief reviews of 16 technologies experiencing high overall or foreign patent activity. Concludes with the series most comprehensive assessment of activity in a given technology, specifically in computer memories.

8. Eighth Report, December 1977*
PB 276375, Cost: Domestic - $7.25 Foreign - $14.50

Reviews U.S. patenting in the context of domestic vs. international patenting and analyze the balance of patenting between the U.S. and other countries. Presents a study demonstrating the uniqueness of patents and the patent file as a technological resource. Concludes with an in-depth analysis of patent activity in geophysical exploration for hydrocarbons.

NTIS Microfilm of Previous Reports
Domestic - $3.00 per report; Foreign - $4.50 per report

*NOTE:

* The Seventh and Eighth Report may also be obtained from the Superintendent of Documents; U.S. Government Printing Office; Washington, D.C. D. C. 20402. Their identification number and cost are: Seventh Report 003-004-00542-4, price: Domestic $4.25, Eighth Report 003-004-00550-5, price: Domestic $3.75.

APPENDIX C
OBTAINING ADDITIONAL INFORMATION OR SPECIAL REPORTS

Background

OTAF's computerized base of data relating to the patent file includes, at present:

- all subclasses of the U.S. Patent Classification System
- the relationship of all subclasses of the U.S. Patent Classification System to the Standard Industrial Classification System in 55 Product Fields and Product Field combinations
- for all U.S. patents, their recorded locations within the U.S. Patent Classification System
- for U.S. patents issued since 1963,
    - . the ownership at time of issue in seven categories (U.S. government, foreign government, U.S. corporation, foreign corporation, U.S. individual, foreign individual, and unassigned)
    - . the country or state of residence of the inventor
- for U.S. patents issued since 1967,
    - . the date the application for patent was filed in the U.S. Patent and Trademark Office.
- for U.S. patents issued since 1969,
    - . the specific (i.e. named) ownership of all patents which, at time of issue, were organizationally owned (e.g., by a corporation, foundation, government agency).
    - . the patent title
- for U.S. patents issued since 1975,
    - . the address of the inventor, and the field of search and references cited in the patentability examination leading to the patent grant.

Special Reports

Data can be retrieved on the basis of any one or any combination of the factors listed above, manipulated on most any given basis and presented in a number of formats, e.g., lists, tables, graphs, charts, etc. This flexibility is illustrated by the various types of reports presented in this Appendix and in the eight OTAF previous general distribution publications.

OTAF has developed several standard special report programs which are designed to extract and present, for any given grouping of patents, a wide variety of data. Excerpts from samples of reports prepared using these programs are included in this Appendix.

STANDARD SPECIAL REPORTS

"Technology Profile" Report

This type of report utilizes most of the elements in OTAF's data base to provide a detailed patent profile for a specific technology. Information provided includes rate of patenting, origin of patenting, general assignment, specific assignment (organization ownership), patent numbers and patent titles. Begining on page 174 is a five page excerpt from a report of this type. The total report -on Color Television- is some 41 pages in length. The first page of the excerpt, titled "Explanation of Data", gives an overview of what is included in one of these reports.

"Organizational Profile" Report

Beginning on page 179 are excerpts from the second of OTAF's standard format special reports. The sample report profiles the patent activity across the classes and subclasses of the U. S. Patent Classification system. A report for Communications Satellite Corp. is given as an example. Two pages of the 24 page report are included. This type of report can be prepared, for example on the patents of any organization or grouping of organizations, or on the patents granted to the residents of any state or country or grouping of states or countries.

Multi-Corporate Patent Activity Profile

Beginning on page 181 is an excerpt from the third of OTAF's standard format special reports. Like the patent activity profile report, this sample report also profiles 1969-1977 patent activity across the classes and subclasses of the U. S. Patent Classification system. In this report, however, the activity of up to eight organizations can be profiled simultaneously, facilitating comparisons between organizations.

SIC Product Field Reports

On pages 183-185 are a listing of Standard Industrial Classification (SIC) Product Fields for which a concordance exists with subclasses of the U. S. Paten Classification System. Special patent reports, such as the "Technology Profile" Report can be prepared for any of these Product Fields.

How to Obtain Special Reports

1. In making an initial determination of interest in a special OTAF report, you are urged to review the data items that are available and decide if any one or combination of them, or any relationship between two or more of them, might be useful to your needs. Special attention should be given to the standard format reports to determine if these multi-purpose, relatively low cost reports would meet your needs.

2. In most instances, interest, once determined, will be limited to particular technological areas or to particular organization owning patents. In the case of technological areas, their definition is of key importance and must ultimately be in terms of classes and subclasses of the U. S. Patent Classification System (or one of the 55 SIC Product Fields or Field combinations). If you are unfamiliar with the U. S. Patent Classification System, develop as clear and precise an explanation of your area(s) of interest as possible. For assignment information, the parent organization and its subsidiaries of interest should be identified. Recent name changes (e. g. Esso-Exxon), if known, should be indicated.

3. At this point, you should contact OTAF, indicate the type of information you desire and, if you wish, what your needs are. (Perhaps alternatives can be suggested to better meet those needs). If you cannot provide class and subclass definition of your area of interest, OTAF will attempt to do that for you, using your description of the area.

4. Once there is a clear mutual understanding of the information you want, the format in which you want it and the area(s) to be included, an estimate of cost will be developed and provided to you along with a statement of the work to be done.

5. Once agreement on work to be done and cost is reached, and payment is received, the report will be prepared and provided.

Costs

All special reports are prepared on a cost reimbursable basis. These costs may vary widely - from as low as $25.00 for some forms of our standard format reports, to several thousand dollars for complex and large scale treatments of many technological categories, requiring extensive professional time, or programming and/or computer time.

Whom to Contact

Inquiries concerning OTAF publications/services are invited and should be directed to:

Office of Technology Assessment
and Forecast
U. S. Patent and Trademark Office
Washington, D. C. 20231
Phone: (703) 557-3050

SAMPLE TECHNOLOGY PROFILE REPORT - COLOR TELEVISION

EXPLANATION OF DATA

Description of Recent Activity

In each report, patent activity is profiled from 1963 - 1977.
activity is profiled from 1963 - 1977.

Each report begins with an "Activity Indices" table. The table presents for the area, information as to the:

- Average Percent Growth, number of patents issued in the period 1975-77 divided by the total number of patents in the period 1968-77.
- Average Percent Foreign, the number of patents issued to residents of foreign countries in the years 1975-77, divided by total number of patents issued in these years.
- Average Percent Corporate Owned, the number of 1975-77 patents assigned at time of issue to U.S. or foreign non-government organizations -- mainly corporations -- divided by the total number of patents issued in this three year period.
- Average Percent Government Owned, the number of 1975-77 patents assigned at time of issue to the U.S. or a foreign government divided by total number of patents issued in this three year period.
- Average percent U.S. Owned of Foreign, the number of 1975-1977 patents with a foreign resident inventor that are assigned to a U.S. organization, divided by the number of patents with a foreign resident inventor in these years.
- XR/OR Ratio, the number of 1975-77 patents with a cross reference designation, divided by the number of patents with an original (primary) designation.

Tables

In the 2nd through 5th pages of each active area report, tables are presented showing by number and percent the patent activity in the area from 1963 through 1977 -first by date of patent grant (2nd and 3rd pages) and then by date of application filing for patents granted from 1967-1977 (4th and 5th pages).

Each of these tables presents the data in several ways:

. Total
. U.S. Origin - inventor a U.S. resident
. Foreign Origin - inventor a foreign resident

The foreign origin data are further subdivided by the country of inventor residence. Data breakdown based on patent ownership is also given both for the U.S. origin patents and the foreign origin patents.

Distributing 1967-1977 patents on an application date basis provides essentially complete data on those applications, which ultimately became patents, filed each year from 1965 through 1975. This is the case because there is a delay between the filing of a patent application and its subsequent issuance as a patent. The length of this delay (i.e., the "pendency" of an application) is determined by many factors, including Patent and Trademark Office workload (which varies between technologies), budget and manpower levels, patent printing schedules, etc.

In 1967, when maintenance of application date data in machine readable form began (and thus became subsequently available for inclusion in the OTAF data base) the average patent pendency was substantially in excess of two years. Consequently, patent applications filed in 1965 and 1966 were not issuing as patents until 1967 or later.

By December of 1977, as a result of an ambitious and successful Patent and Trademark Office program, the average pendency had been reduced to about 19 months. This current average pendency renders the patents by application date data shown for years subsequent to 1975 (i.e., 1976-1977 incomplete. The obvious reason for this is that a significant number of the applications filed in 1976 and 1977 are still pending, have not, as yet, appeared as patents and, therefore, are not reflected in the OTAF data base.

It should note that only applications which ultimately matured into patents are reflected in the application date data. Those applications which were filed but never issued (roughly 30% of total filings) are not included.

OTAF feels that the application date data are of significant value, for the date an application is filed is a more accurate reflection of when the technology was developed. Additionally, fluctuation in data based on application date is much more likely to reflect changes in technological activity, since such fluctuation would, for the most part, be immune from, rather than the result of changes in Patent and Trademark Office application processing.

Following the tables is a distribution of organizational patenting by patent assignees having received, from January 1969 through December 1977, a number of patents equal to or greater than a given "cut-off" number (indicated in page heading). This patenting is given, by year, both by patent grant date and by patent application date. The specific patent numbers are listed, by assignee, at the end of the report. Patents without assignee information are given last. Patent titles are given for all 1969-1977 patents.

Patents Included in Profiles

The user should be aware that patent activity profiles are generated by first identifying key Patent and Trademark Office classifications, i.e. those entirely or substantially pertinent to the technology of interest. All the patents in these calssifications are included in the profile. This procedure results, in most cases, with the inclusion of the majority of patents relevant to the technology and few, if any non-relevant patents. However, SIC system and the Patent and Trademark Office Classification system and the concordance between the two is seldom one-to-one. Consequently, any patent listing provided should not be considered to be inclusive of all relevant patents, nor exclusive of all non-relevant patents.

OTAF SPECIAL REPORT - COLOR TELEVISION

PATENT ACTIVITY (1963-1977) BY DATE OF PATENT GRANT

NUMBER OF PATENTS

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	TOTAL
TOTAL	52	43	46	94	89	57	102	172	236	174	235	164	132	167	177	1940
U.S. ORIGIN	40	30	35	54	57	44	73	117	147	101	117	85	66	84	90	1140
FOREIGN ORIGIN	12	13	11	40	32	13	29	55	89	73	118	79	66	83	87	800
JAPAN	1	1	2	9	8	2	7	18	32	38	73	47	37	48	48	371
GERMANY		1	1	3	5	5	6	13	21	13	16	13	8	7	9	121
UNITED KINGDOM	7	5	4	10	5	2	6	3	8	9	3	5	8	10	8	93
NETHERLANDS	1	2	2	8	5	1	3	3	13	5	14	7	6	10	8	88
FRANCE	3	3	2	7	6	3	4	5	4	2	5	3	1	5	8	61
CANADA							1	5	7	3	4	1	1	2	1	25
SWITZERLAND		1		3	1		2	3	3	3		2	1		2	21
AUSTRIA								1	1		1	1	2	1		7
U.S.S.R.								1					2			3
ITALY															2	2
BELGIUM								1			1					2
CZECHOSLOVAKIA					1											1
HUNGARY					1											1
ICELAND								1								1
															1	1
ARGENTINA								1								1
ISRAEL											1					1
U.S. ORIGIN	40	30	35	54	57	44	73	117	147	101	117	85	66	84	90	1140
U.S. CORP. OWNED	35	27	28	48	45	37	65	113	134	90	102	73	58	74	78	1007
U.S. GOVT. OWNED			1		1				2	3	2	1	1	3		14
U.S. INDIV. OWNED	5	3	6	6	10	7	8	4	10	8	13	11	7	4	10	112
FOREIGN OWNED					1				1					3	2	7
FOREIGN ORIGIN	12	13	11	40	32	13	29	55	89	73	118	79	66	83	87	800
U.S. OWNED	4	8	4	12	6	2	7	10	26	14	16	13	9	15	13	159
FOREIGN OWNED	8	5	7	28	26	11	22	45	63	59	102	66	57	68	74	641
FOREIGN CORP.	8	4	5	25	23	11	19	41	60	56	97	62	54	67	72	604
FOREIGN GOVT.							1								1	2
FOREIGN INDIV.		1	2	3	3		2	4	3	3	5	4	3	1	1	35

OTAF SPECIAL REPORT - COLOR TELEVISION

PATENT ACTIVITY (PATENTS GRANTED 1/67-12/77) BY DATE OF PATENT APPLICATION

NUMBER OF PATENTED APPLICATIONS

	PRE 64	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	TOTAL
TOTAL	21	53	85	122	127	127	143	178	182	169	130	139	156	72		1704
U.S. ORIGIN	13	34	58	89	84	80	89	98	98	82	64	73	81	37		980
FOREIGN ORIGIN	8	19	27	33	43	47	54	80	84	87	66	66	75	35		724
JAPAN	2	5	8	8	10	16	23	48	50	49	39	40	38	22		358
GERMANY	1	2	8	11	9	12	10	13	10	16	9	4	7	4		116
UNITED KINGDOM	1	5	3	5	2	4	6	6	4	5	6	6	13	1		67
NETHERLANDS	1	2	3	1	7	5	7	5	12	9	6	9	3	5		75
FRANCE	3	3	3	4	7		2	2	4	3	2	3	9	1		46
CANADA					6	5	3	2	3	2		2	1	1		25
SWITZERLAND			2	1	2	3	1	2	1	2		2	1			17
AUSTRIA				1		1		1		1	2		1			7
U.S.S.R.				1							2					3
ITALY													1	1		2
BELGIUM				1			1									2
CZECHOSLOVAKIA		1														1
HUNGARY		1														1
ICELAND						1										1
													1			1
ARGENTINA							1									1
ISRAEL								1								1
U.S. ORIGIN	13	34	58	89	84	80	89	98	98	82	64	73	81	37		980
U.S. CORP. OWNED	8	26	49	78	81	76	83	87	82	74	53	66	69	36		868
U.S. GOVT. OWNED			1			1	1	1	2	3	1	2	1			13
U.S. INDIV. OWNED	5	8	8	10	3	3	4	10	14	5	10	2	9	1		92
FOREIGN OWNED				1			1					3	2			7
FOREIGN ORIGIN	8	19	27	33	43	47	54	80	84	87	66	66	75	35		724
U.S. OWNED	1	3	5	7	11	15	10	13	16	12	10	12	8	8		131
FOREIGN OWNED	7	16	22	26	32	32	44	67	68	75	56	54	67	27		593
FOREIGN CORP.	7	16	17	24	29	31	42	63	63	73	52	53	66	26		562
FOREIGN GOVT.			1										1			2
FOREIGN INDIV.			4	2	3	1	2	4	5	2	4	1		1		29

OTAF SPECIAL REPORT - COLOR TELEVISION

ORGANIZATIONAL PATENTING (1/69-12/77) -- ORGANIZATIONS WITH 5 OR MORE PATENTS

	PRE 64	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	TOTAL
RCA CORPORATION																
PATENTS GRANTED							9	21	41	24	23	16	13	28	33	208
PATENTED APPLICATIONS			2	9	11	27	24	21	19	16	10	22	33	13		208
SONY CORPORATION																
PATENTS GRANTED							2	8	14	14	21	15	8	11	22	115
PATENTED APPLICATIONS				2	6	7	8	15	18	14	8	8	19	10		115
U.S. PHILIPS CORPORATION																
PATENTS GRANTED							1	8	18	8	15	8	7	12	11	88
PATENTED APPLICATIONS			2	2	6	11	7	8	13	9	8	10	6	6		88
MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.																
PATENTS GRANTED								1	3	4	13	10	7	10	6	54
PATENTED APPLICATIONS				1		1	4	8	6	10	9	10	3	2		54
ZENITH RADIO CORPORATION																
PATENTS GRANTED							7	7	13	9	7	2	2	4		51
PATENTED APPLICATIONS			1	6	6	5	8	9	5	4	4	2	1			51
MOTOROLA INC.																
PATENTS GRANTED							7	7	11	5	6	7	4	2	2	51
PATENTED APPLICATIONS				6	6	4	10	4	3	8	4	4	1	1		51
GENERAL ELECTRIC COMPANY																
PATENTS GRANTED							7	3	9	4	12	5	2	3	3	48
PATENTED APPLICATIONS		2	3	4		2	4	9	8	7	2	4	1	2		48
GTE SYLVANIA INCORPORATED																
PATENTS GRANTED							6	12	10	6	3	2	2	3	1	45
PATENTED APPLICATIONS				5	9	11	2	7	1	3	2	2	3			45
HITACHI, LTD.																
PATENTS GRANTED									3	5	5	8	6	9	4	40
PATENTED APPLICATIONS						1	2	5	6	6	7	8	4	1		40
FERNSEH GMBH DARMSTADT																
PATENTS GRANTED								7	13	10	8	2				40
PATENTED APPLICATIONS				3	4	7	9	9	4	4						40
CBS INC.																
PATENTS GRANTED							7	4	9	3	6	2		1	4	36
PATENTED APPLICATIONS	1			8	3	3	6	2	3	3	2	1	1	3		36
BELL TELEPHONE LABORATORIES INCORPORATED																
PATENTS GRANTED							1	5	1	8	5	3	1	3	1	28
PATENTED APPLICATIONS				1	2	3	2	6	4	4	2	3		1		28
VICTOR COMPANY OF JAPAN, LIMITED																
PATENTS GRANTED							1	2	2	5	6	3	1	4	3	27
PATENTED APPLICATIONS		1		1	1		4	6	1	4	2	3	2	2		27
EASTMAN KODAK COMPANY																
PATENTS GRANTED										1	4	4	2	2	8	21
PATENTED APPLICATIONS								2	4	4		1	5	5		21

ADMIRAL CORPORATION
- 3492413 - TRANSISTOR COLOR DEMODULATOR WITH D.C. STABILIZATION
- 3492414 - BLANKING CIRCUIT FOR A COLOR TELEVISION RECEIVER
- 3519734 - CHROMA BLANKING CIRCUIT
- 3519735 - NON-MATRIXING BLANKING CIRCUIT
- 3562412 - VARIABLE COUPLING IF AMPLIFIER INCLUDING A DOUBLE- TUNED CIRCUIT
- 3688021 - TINT CONTROL
- 3896330 - COLOR TELEVISION DEGAUSSING CIRCUIT
- 3924067 - AUTOMATIC BEAM CURRENT LIMITER WITH VIDEO HOLD-OFF

AERONUTRONIC FORD CORPORATION (FORMERLY PHILCO-FORD CORP.)
- 3595989 - DC COUPLED CHROMA PROCESSING INTEGRATED CIRCUIT
- 3598905 - WHITE-BALANCE SERVICING CIRCUIT
- 3613105 - COLOR MATRIX CIRCUIT
- 3943279 - DIGITAL CONVERGENCE OF MULTIPLE IMAGE PROJECTORS
- 3996611 - CATHODE RAY TUBE DEFLECTION CIRCUIT

AGFA-GEVAERT
- 3510571 - LIGHT BEAM MODULATION AND COMBINATION APPARATUS
- 3731994 - METHOD OF RECORDING. DUPLICATING AND REPRODUCING IMAGES IN THE FORM OF RELIEF PATTERNS
- 3737574 - SYSTEM FOR REPRODUCING COLOR IMAGES
- 3761609 - METHOD AND APPARATUS FOR RECORDING AND REPRODUCING IMAGES ON CONTINUOUSLY MOVING CINEMATOGRAPHIC FILM
- 3820992 - METHOD AND APPARATUS FOR RECORDING COLOR PICTURE INFORMATION ON PHOTOGRAPHIC MATERIAL
- 3860950 - METHOD AND APPARATUS FOR RECORDING AND READING OUT HOLOGRAMS ON BLACK-AND-WHITE FILM
- 3891975 - METHOD AND ARRANGEMENT FOR RECORDING THE PHASE DISTRIBUTION OF AN OBJECT WAVE STORED IN A HOLOGRAM
- 4017891 - METHOD AND EQUIPMENT FOR LINE-BY-LINE RECORDING OF COLOR COMPONENT IMAGES ON A REPRODUCTION CARRIER

AMPEX CORPORATION
- 3428745 - HEAD-TO-TAPE VELOCITY ERROR COMPENSATOR FOR ROTARY HEAD VIDEO TAPE RECORDERS
- 3506777 - APPARATUS FOR REPRODUCING COLOR TELEVISION SIGNALS WHEREIN A PILOT SIGNAL IS UTILIZED FOR ELIMINATING HUE ERRORS DUE TO TIME BASE VARIATIONS
- 3562413 - SWITCHING SEQUENCE DETECTOR FOR P.A.L. COLOR TELEVISION
- 3564123 - CHROMA INVERTER
- 3763317 - SYSTEM FOR CORRECTING TIME-BASE ERRORS IN A REPETITIVE SIGNAL
- 3781464 - LIGHT SCANNING APPARATUS AND METHOD FOR CONVERTING DISPLAY INFORMATION INTO STORABLE VIDEO DATA
- 3838310 - AUTO CENTERING FOR MULTIPLE TUBE TELEVISION COLOR CAMERAS
- 3994013 - LAST LINE VELOCITY COMPENSATION
- 4034397 - PILOT SIGNAL LUMINANCE CORRECTION MEANS FOR VIDEO RECORDING APPARATUS
- 4052740 - MOIRE INTERFERENCE REDUCING CIRCUIT FOR FM VIDEO RECORDERS
- 4053926 - TIMING ERROR COMPENSATOR

BASF AKTIENGESELLSCHAFT
- 3921203 - TRISEQUENTIAL COLOR VIDEO RECORD-PLAYBACK METHOD AND CIRCUITS
- 3946431 - SYNCHRONIZED DEMODULATION OF THE CHROMINANCE SIGNAL WITH SWITCHED CARRIER PHASE ANGLES
- 3952326 - DROPOUT COMPENSATOR FOR A TRISEQUENTIAL COLOR VIDEO PLAYBACK SYSTEM
- 3969758 - SYNCHRONIZING SYSTEM FOR VIDEO RECORDERS
- 4005473 - METHOD AND APPARATUS FOR SYNCHRONIZING RECORD AND PLAYBACK OF VIDEO SIGNALS
- 4051517 - HYBRID SEQUENTIAL AND CARRIER ENCODED COLOR TELEVISION TRANSMISSION METHOD AND CIRCUITS

BELL + HOWELL COMPANY
- 3440341 - TWO-COLOR DISPLAY FROM LINE SEQUENTIAL COLOR RECORDING
- 3456069 - COLOR SYNCHRONIZATION FOR TWO COLOR PER LINE TELEVISION SYSTEMS
- 3512094 - ELECTRONIC SIGNAL PROCESSING SYSTEMS
- 3531584 - COLOR VIDEO CAMERA AND IMAGE RECORDING SYSTEMS UTILIZING STRIPED FILTERS
- 3536827 - COLOR HUE ERROR CORRECTION APPARATUS
- 3542947 - VIDEO DISPLAY OF LINE SEQUENTIAL COLOR SIGNAL
- 3557302 - ONE-CHANNEL SIGNAL CONVEYING SYSTEMS FOR LUMINANCE AND CHROMINANCE VIDEO SIGNALS

SAMPLE ORGANIZATIONAL PROFILE REPORT - COMMUNICATIONS SATELLITE CORPORATION
EXPLANATION OF DATA

DESCRIPTION OF PATENT PROFILES

THE REPORT PROFILES ONLY THOSE PATENTS FALLING INTO A PARTICULAR "CATEGORY" (E.G., SPECIFIC OWNERSHIP, COUNTRY OR STATE OF INVENTOR RESIDENCE), BY THE U.S. PATENT CLASSIFICATIONS INTO WHICH THOSE PATENTS HAVE BEEN PLACED.

EACH MAJOR PATENT CLASSIFICATION (CLASS) IS IDENTIFIED BY ITS TITLE. THEN, FOR EACH OF THE SUBCLASSES WITHIN THAT CLASS WHEREIN PATENTS FROM THE "CATEGORY" HAVF BEEN PLACED, THE FOLLOWING ARE GIVEN:

--TOTAL PATENTS
--OR (ORIGINAL) PATENTS
--XR (CROSS-REFERENCE) PATENTS
--PCT (PERCENT) OF TOTAL OR WITHIN THE "CATEGORY"
--PCT (PERCENT) OF ALL (OR & XR) PATENTS WITHIN THE "CATEGORY"

ALSO GIVEN ARE THE PATENT NUMBERS OF THE "CATEGORY" PATENTS IN THAT CLASSIFICATION. THE TYPE OF CLASSIFICATION (OR orXR) ASSIGNED TO EACH PATENT IS SHOWN IN PARENTHESES FOLLOWING THE PATENT.

FOR PATENTS ISSUING IN 1969 AND SUBSEQUENTLY, THE PATENT TITLES ARE GIVEN. (NOTE: ANY SYMBOLS IN A PATENT TITLE WHICH ARE NOT AVAILABLE ON THE COMPUTER PRINTER ARE SPELLED OUT, EG., β IS SHOWN AS BETA. SUPERSCRIPTS AND SUBSCRIPTS ARE INDICATED BY ENCLOSURE BETWEEN UPWARDLY OR DOWNWARDLY FACING SLASHES, E.G., H_2O IS SHOWN AS H/2 \O AND Y^2X IS SHOWN AS Y \2/X.)

PATENTS INCLUDED IN PROFILE

THE PATENTS INCLUDED IN THE REPORT ARE THOSE WHICH, ACCORDING TO THE DATA OF RECORD IN THE OTAF COMPUTER DATA BASE, FALL WITHIN THE CATEGORY COVERED IN THE REPORT. THESE CATEGORY DATA ARE RECORDED AT THE TIME OF PATENT ISSUE AND ARE ESSENTIALLY ACCURATE. HOWEVER, ANY PATENT LISTING OR DATA PROVIDED IN THIS REPORT SHOULD NOT BE CONSIDERED TO BE INCLUSIVE OF ALL RELEVANT PATENTS, NOR EXCLUSIVE OF ALL NON-RELEVANT PATENTS.

CLASS 324 - ELECTRICITY, MEASURING AND TESTING

SUBCLASS 95 TOTAL 1 (OR) 1 (XR) 0 PCT OF TOTAL OR .7 PCT OF ALL (OR+XR) .2

3890571 (OR) - RADIO FREQUENCY POLARIMETER

SUBCLASS 158 F TOTAL 1 (OR) 0 (XR) 1 PCT OF TOTAL OR 0.0 PCT OF ALL (OR+XR) .2

3775644 (XR) - ADJUSTABLE MICROSTRIP SUBSTRATE HOLDER

TOTAL CLASS 324 TOTAL 2 (OR) 1 (XR) 1 PCT OF TOTAL OR .7 PCT OF ALL (OR+XR) .4

CLASS 325 - MODULATED CARRIER WAVE COMMUNICATION SYSTEMS

SUBCLASS 1 TOTAL 1 (OR) 0 (XR) 1 PCT OF TOTAL OR 0.0 PCT OF ALL (OR+XR) .2

3931623 (XR) - RELIABLE EARTH TERMINAL FOR SATELLITE COMMUNICATIONS

SUBCLASS 2 TOTAL 2 (OR) 1 (XR) 1 PCT OF TOTAL OR .7 PCT OF ALL (OR+XR) .4

3778715 (OR) - TDMA SATELLITE COMMUNICATIONS SYSTEM WITH RAPID AUTOMATIC RE-ENTRY FOLLOWING BRIEF OUTAGES OF EARTH STATION EQUIPMENT
3942115 (XR) - DUAL PILOT REDUNDANT AFC SYSTEM FOR SATELLITE COMMUNICATIONS SYSTEM

SUBCLASS 3 TOTAL 4 (OR) 2 (XR) 2 PCT OF TOTAL OR 1.4 PCT OF ALL (OR+XR) .8

3810255 (OR) - FREQUENCY TRANSLATION ROUTING COMMUNICATIONS TRANSPONDER
3917998 (OR) - BUTLER MATRIX TRANSPONDER
3928804 (XR) - ZONE SHARING TRANSPONDER CONCEPT
3942115 (XR) - DUAL PILOT REDUNDANT AFC SYSTEM FOR SATELLITE COMMUNICATIONS SYSTEM

SUBCLASS 4 TOTAL 26 (OR) 5 (XR) 21 PCT OF TOTAL OR 3.6 PCT OF ALL (OR+XR) 5.3

3566267 (OR) - BURST SYNCHRONIZATION METHOD AND APPARATUS
3812430 (OR) - TDMA SATELLITE COMMUNICATIONS SYSTEM WITH IMPROVED ACQUISITION
3818453 (OR) - TDMA SATELLITE COMMUNICATIONS SYSTEM
3928804 (OR) - ZONE SHARING TRANSPONDER CONCEPT
3942115 (OR) - DUAL PILOT REDUNDANT AFC SYSTEM FOR SATELLITE COMMUNICATIONS SYSTEM
3526719 (XR) - DOUBLE APERTURE TECHNIQUE FOR DETECTING STATION IDENTIFYING SIGNAL IN A TIME DIVISION MULTIPLE ACCES S SATELLITE COMMUNICATION SYSTEM
3617644 (XR) - SATELLITE COMMUNICATION EXCHANGE STATION
3644678 (XR) - CHANNEL REALLOCATION SYSTEM AND METHOD
3562432 (XR) - SYNCHRONIZER FOR TIME DIVISION MULTIPLE ACCESS SATELLITE COMMUNICATION SYSTEM
3564147 (XR) - LOCAL ROUTING CHANNEL SHARING SYSTEM AND METHOD FOR COMMUNICATIONS VIA A SATELLITE RELAY
3634628 (XR) - METHOD AND APPARATUS FOR FORMING TDM SIGNAL BURSTS FOR A TIME DIVISION MULTIPLE ACCESS SATELLITE COM MUNICATION SYSTEM
3649764 (XR) - VARIABLE BURST LENGTH TDMA SYSTEM
3654395 (XR) - SYNCHRONIZATION OF TDMA SPACE DIVISION SATELLITE SYSTEM
3683116 (XR) - TERRESTRIAL INTERFACE UNIT
3730998 (XR) - TDMA SATELLITE COMMUNICATIONS SYSTEM WITH AN APERTURE WINDOW FOR ADQUISITION
3772475 (XR) - SATELLITE COMMUNICATIONS SYSTEM WITH SUPER FRAME FORMAT AND FRAME SEGMENTED SIGNALLING
3778715 (XR) - TDMA SATELLITE COMMUNICATIONS SYSTEM WITH RAPID AUTOMATIC RE-ENTRY FOLLOWING BRIEF OUTAGES OF EARTH STATION EQUIPMENT

SAMPLE MULTI - CORPORATE PATENT ACTIVITY PROFILE

EXPLANATION OF DATA

DESCRIPTION OF PATENT PROFILES

THE REPORT PROFILES PATENTS ASSIGNED TO UP TO EIGHT COMPANIES BY THE CURRENT U.S. PATENT CLASSIFICATIONS INTO WHICH THOSE PATENTS HAVE BEEN PLACED.

EACH CLASS IS IDENTIFIED BY ITS TITLE. THEN FOR EACH CLASS AND SUBCLASS WITHIN THAT CLASS, COMPANY PATENTING IS GIVEN BOTH IN TERMS OF THE NUMBER OF PATENTS IN THAT CLASSIFICATION (TOTAL) AND THE PERCENTAGE OF ALL PATENTS TO THAT COMPANY (PCT).

ONLY ORIGINAL (OR) CLASSIFICATION OF PATENTS HAVE BEEN CONSIDERED IN THIS REPORT.

PATENTS INCLUDED IN PROFILE

THE PATENTS INCLUDED IN THE REPORT ARE THOSE WHICH, ACCORDING TO THE DATA OF RECORD IN THE OTAF COMPUTER DATA BASE, FALL WITHIN THE CATEGORY COVERED IN THE REPORT. THESE CATEGORY DATA ARE RECORDED AT THE TIME OF PATENT ISSUE AND ARE ESSENTIALLY ACCURATE. HOWEVER, ANY PATENT LISTING OR DATA PROVIDED IN THIS REPORT SHOULD NOT BE CONSIDERED TO BE INCLUSIVE OF ALL RELEVANT PATENTS, NOR EXCLUSIVE OF ALL NON-RELEVANT PATENTS.

	WESTERN ELEC		BURROUGHS		CONTROL DATA		DIG EQUIP		GTE SYLVANIA		GENERAL ELEC		HONEYWELL		I B M	
	TOTAL	PCT	TOTAL	PCT	TOTAL	PCT	TOTAL	PCT	TOTAL	PCT	TOTAL	PCT	TOTAL	PCT	TOTAL	PCT
CLASS 361 - ELECTRICITY, ELECTRICAL SYSTEMS AND DEVICES																
SUBCLASS 404									1	.1						
SUBCLASS 409															1	.0
SUBCLASS 411											1	.0				
SUBCLASS 413					1	1.1	1	2.2	1	.1						
SUBCLASS 414															1	.0
SUBCLASS 415	1	.0							3	.2	1	.0	2	.2		
SUBCLASS 416									1	.1	1	.0				
SUBCLASS 424									1	.1						
SUBCLASS 428	1	.0														
SUBCLASS 433	2	.1									7	.2	1	.1	1	.0
SUBCLASS 434											1	.0				
TOTAL CLASS 361	28*	1.0	9*	1.6	2*	2.2	1*	2.2	29*	2.1	141*	3.1	17*	1.6	25*	.9
CLASS 364 - ELECTRICAL COMPUTERS AND DATA PROCESSING SYSTEMS																
SUBCLASS 200	27	.9	69	12.5	3	3.3	15	33.3	26	1.8	7	.2	104	10.0	160	5.8
SUBCLASS 300	6	.2	1	.2	1	1.1							4	.4	5	.2
SUBCLASS 900	18	.6	6	1.1	1	1.1			7	.5	11	.2	7	.7	52	1.9
TOTAL CLASS 364	51*	1.8	76*	13.8	5*	5.4	15*	33.3	33*	2.3	18*	.4	115*	11.1	217*	7.8
CLASS 403 - JOINTS AND CONNECTIONS																
SUBCLASS 11											2	.0				
SUBCLASS 15											1	.0				
SUBCLASS 28											1	.0				
SUBCLASS 104	1	.0														

SIC PRODUCT FIELDS

PRODUCT FIELDS	SIC CATEGORY
Food and Kindred Products	20
Textile Mill Products	22
Chemicals and Allied Products	28
Chemicals, Except Drugs & Medicines	281, 282, 284-289
Basic Industrial Inorganic & Organic Chemistry	281, 286
Industrial Inorganic Chemistry	281
Industrial Organic Chemistry	286
Plastics Materials & Synthetic Resins	282
Agricultural Chemicals	287
All Other Chemicals	284, 285, 289
Soap, Detergents, and Cleaning Preparations, Perfumes, Cosmetics & Other Toilet Preparations	284
Paints, Varnishes, Lacquers, Enamels, and Allied Products	285
Miscellaneous Chemical Products	289
Drugs and Medicines	283
Petroleum & Natural Gas Extraction & Petroleum Refining	13, 29
Rubber & Miscellaneous Plastics Products	30
Stone, Clay, Glass and Concrete Products	32
Primary Metals	33, 3462, 3463
Primary Ferrous Products	331, 332, 3399, 3462
Primary & Secondary Non-Ferrous Metals	333-336, 339 (except 3399), 3463
Fabricated Metal Products	34 (except 3462, 3463, 348)

PRODUCT FIELDS	SIC CATEGORY
Machinery, Except Electrical	35
Engines & Turbines	351
Farm & Garden Machinery & Equipment	352
Construction, Mining & Material Handling Machinery & Equipment	353
Metal Working Machinery & Equipment	354
Office Computing & Accounting Machines	357
Other Machinery, Except Electrical	355, 356, 358, 359
Special Industry Machinery, Except Metal Working Machinery	355
General Industrial Machinery & Equipment	356
Refrigeration & Service Industry Machinery	358
Miscellaneous Machinery, Except Electrical	359
Electrical and Electronic Machinery, Equipment and Supplies	36, 3825
Electrical Equipment, Except Communication Equipment	361-364, 369, 3825
Electrical Transmission & Distribution Equipment	361, 3825
Electrical Industrial Apparatus	362
Other Electrical Machinery, Equipment & Supplies	363, 364, 369
Household Appliances	363
Electrical Lighting & Wiring Equipment	364
Miscellaneous Electrical Machinery, Equipment & Supplies	369

PRODUCT FIELD	SIC CATEGORY
Communication Equipment & Electronic Components	365-367
Radio & Television Receiving Equipment, Except Communication Types	365
Electronic Components & Accessories & Communication Equipment	366-367
Transportation Equipment	37, 348
Motor Vehicles & Other Transportation	348, 371, 373-376, 379
Motor Vehicles & Motor Vehicles Equipment	371
Guided Missiles & Space Vehicles & Parts	376
Other Transportation Equipment	373-375, 379 (except 3795)
Ship & Boat Building & Repairing	373
Railroad Equipment	374
Motorcycles, Bicycles & Parts	375
Miscellaneous Transportation Equipment	379 (except 3795)
Ordinance Except Missiles	348, 3795
Aircraft & Parts	372
Professional & Scientific Instruments	38 (except 3825)

APPENDIX D

ACKNOWLEDGEMENTS

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OFFICE OF TECHNOLOGY ASSESSMENT AND FORECAST

Staff:

William S. Lawson, Director
John F. Terapane, Ph.D., Senior Analyst
Donald G. Kelly, Senior Analyst
Gary R. Robinson, Data Control and Analysis Technician
Terry D'Amico, Secretary
Lisa A. Ferrari, Publication Aid
Melissa J. Benitez, Publication Aid

Ferrous Metal Special Report:

Peter D. Rosenberg, Patent Examiner (Principal Author)
R. Spencer Annear, Patentability Review Examiner (Continuous Casting)
John F. Terapane, Senior Analyst (Patent Activity Analysis)

Graphics:

Chester A. Pawlaczyk, Draftsman
William J. Sales, Draftsman

Report Preparation Support:

Therese Boisvert, Economist
Sharon G. Carpenter, Researcher
Albyn Jones, Statistician
Ronald L. Knickerbocker, Bibliopegist
Thomas True, Writer-Editor
Elizabeth Weiler, Economist

CONSULTANTS

Melvyn J. Andrews
Paul A. Bell
E.J. Demesme
John Dewhirst
Gerald A. Dost
Sally M. Hayden
O. A. Neuman
Robert J. Rish
L. Dewayne Rutledge

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